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The cultural heritages of water in tropical and subtropical Eastern and South-Eastern Asia

Thematic Study

Compilation of articles

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Table of contents

1. Introduction

The Cultural Heritages of Water in Tropical and Subtropical Eastern and South-Eastern Asia

By Michel J. Cotte, Emeritus Professor of the University of Nantes, ICOMOS Advisor

ICOMOS launched a series of thematic studies on water management as cultural heritage, based on a regional approach in the 2010s. The initially studied region resulted in a first volume, dedicated to 'The Cultural Heritages of Water in the Middle East and Maghreb', which was first drafted and edited in 2015. A revised and expanded version was published in 2017.[1] In the introduction to this first volume, we described how this new heritage theme must be understood, especially in the spirit of the World heritage Convention.[2]

The most important features emerging from this study related to arid and desert countries with a permanent lack of water and the need for sophisticated devices to gather, conserve and manage water for development of human communities. The Thematic Study offered an impressive panorama of human ability for such practices and their demonstration of long-lasting human efforts. This then led to the realisation that in the Middle East and Maghreb, from the ancient time of Islam to the modern period, water harvesting, and water management have held a central place. Innovation diffused from country to country, changing names, reached a high and sophisticated technical level that supported the development of the area. Water culture is therefore an essential parameter of the Middle East and Maghreb civilisation.

With the study we aimed to enlighten and to explore a kind of paradigmatic regional situation for the management of water as cultural heritage. A couple of reasons had drawn our attention to this idea: first the unity and continuity of climate context, from arid to semi-arid and Mediterranean zones, and second, the long-term Islamic civilisation which united all these countries had been especially favourable for the diffusion of techniques, scientific knowledge, innovation, and good practice. Furthermore, we were concerned by the lack of attention to this type of 'everyday' tangible heritage, both from the perspective of individuals and heritage administration. This was an obvious, omnipresent human heritage part of the daily rhythm, beyond the classical interest in cultural heritage. These vernacular statements from our past, seemingly unoriginal and omnipresent, are viewed as a practical facility and not as a major heritage and precious legacy from past times.

Our project and publication met with real interest and audience in the region, e.g., during the World Heritage Committees of Doha (2014) and Bahrain (2018). The Arab Regional Centre for World Heritage in Bahrain (ARC-WH) gave special visibility to this thematic study through a public exhibition and translation of the volume into the Arabic language.[3] One important result was the fuelling of interest within diverse State parties of the region towards their water management heritage, expressed through heritage projects, studies and protection plans. It is also an enlargement of the World Heritage Themes as recommended by the Global Strategy for a representative, balanced and credible World Heritage List[4]. The goal was also to invite States parties to pay more attention to water attributes and significances related to large and complex nominations, as is the case with historical centres or cultural landscapes.

[1] Michel Cotte (ed.), *Cultural Heritages of Water, Middle East and Maghreb*, Paris, ICOMOS Thematic Study, 2015, revised edn. 2017. https://www.icomos.org/en/116-english-categories/resources/publications/3802-icomos-thematic-study-on-the-cultural-heritages-of-water-in-the-middle-east-and-the-maghreb

[2] *Op. mentioned*, pp. 9–24.

[3] http://arcwh.org/fr/news/launch-of-arabic-version-of-the-thematic-study-the-cultural-heritage-of-water-in-the-middle east-and-the-maghreb

[4] *Operational Guidelines for the Implementation of the World Heritage Convention*, Paris, UNESCO, 2019, pp. 54–61.

This new thematic study follows considerable reflection and multiple actions at international level, particularly under the auspices of the various agencies of the UN, UNESCO, and specialised NGOs with acknowledged expertise. The focus of these organisations is guided by a concern to encourage the sustainable development of human societies, and particularly to help master the technical, social, and cultural factors linked to the access and use of water. In this context, a better knowledge and understanding of traditional cultural heritages linked to water would seem to be a necessary and useful, approach.

The initial aim of the approach we are adopting here is to help with recognising, studying and preserving this type of heritage. From this viewpoint, the framework provided by the World Heritage Convention is an important tool to provide instructive insights. This can perhaps play an even more important role in providing a methodology for the identification and further the preservation of such heritages, in a wider context, e.g. for properties of regional or local importance. A distinction must be drawn here between living heritages, which are still active in supporting contemporary human communities, and archaeological heritages or relict landscapes, which bear witness to the societies of the past. Finally, an international water heritage which is appropriately identified, and whose true value is recognised, can constitute a thesaurus of sustainable technical solutions whose tangible, social and energy costs are reasonable when compared to the extreme responses of contemporary techno-science applied to the field of water.

Water has a special place among the many relationships which exist between man and nature. It is a permanent and essential human need. Access to water is a vital element common to all human civilisations; there are no exceptions, reiterating that all civilisations have a water culture. Societies attempt at sustainably controlling this relationship of dependency manifested in all its various components. Water is a prerequisite for human survival and the consequence is understood, that, if they do not succeed, their collective future will be compromised, in a medium and long-term perspective.

A distinction should be drawn between fresh water and salt water. We have limited the field of heritage considered here to fresh water and inland water. Water meets essential individual and collective needs, but these needs are constantly evolving, because of the demography of societies and changes in uses in the many fields of human activity. The needs may be direct (food, hygiene, etc.) or indirect (agriculture, industry, energy, transport, etc.). Moreover, water, as a raw material, is rarely a pure product, as it contains mineral salts and often important and varied pollutants.

Every civilisation always produces tangible equipment and social rules intended to ensure that the many needs outlined above are met. It must also be able to cope with evolution and changes in the parameters of water resources. Civilisation produces technical and collective organisation factors, which are linked to the management and uses of water. Each one has produced a water culture which we can learn from the heritages we have inherited, in the form of living or archaeological evidence, whose components are directly connected to regional and local hydrological and climatic data.

Tropical and subtropical countries in Eastern and South-eastern Asia have retained our attention for pursuing ICOMOS work on water management as cultural heritage, by way of this new study. It is related to a world region with well identified and strong common characteristics both for its climate conditions and sharing common cultural values, such as the monsoon phenomenon, the 'rice civilisation', historical influences of shared religions such as Buddhism, mutual influences and exchanges through history, technical practices for construction and arts, etc.

This is an inherently different regional context than the arid and semi-arid Middle East and Maghreb, but we pursue the same general overarching goal of heritage identification and understanding. Monsoon periods and least humid seasons can vary from one geographical sub-region to another, reiterating the contrast in water management practiced by diverse civilisations. Of course, it is difficult to clearly define the limits of this new Thematic Study, especially in the context of South-eastern Asia, where geo-climatic conditions and cultural contacts along history are important with Southern Asia and with the archipelagos of the Indian Ocean located in close proximity. A future volume will be dedicated to this southern part of Asia, a typically tropical region. We decided to limit our approach here so that this volume can remain sufficiently coherent for readers.

Irrigation appears as a basic technical and cultural feature of this tropical region. Some of the hydraulic systems are exceptionally large, ancient and technically impressive. The variety and subtlety of irrigation, balanced by effective drainage, is essential to manage both scarcity and excess water on the land. For all these reasons, this region must be studied for itself and with care. It offers specific examples resulting from choices on water catchment, on its transport, on its regulation with large-scale devices, also for flood control. The result is sometimes very impressive civil and hydraulic engineering. Other uses of water led to important initiatives for land transport through canals, military defence, etc.

Rivers themselves are to be considered important heritage, both natural and cultural, for their major economic and social functions, e.g., for boat urbanism, for religious and symbolic ceremonies, etc. It should be similar for freshwater springs, or some wetlands. The ethnography of water uses, relying on natural and cultural values, should bear important intangible meanings. The array of technical examples and diversity of significances will be larger than we can imagine at the starting point of the project.

Several major topics arise from this programme, in relation to the defined region, with its geo-climatic conditions and its history. They offer the content for this volume which, in brief, covers:

- Water capture and networks of water supply at local-medium scale / associated hydraulic engineering and hydraulic management / associated intangible features;
- Water reservoirs and water control / large-scale water networks / associated engineering and associated intangible value;
- River flood control / dikes and water regulation;
- Water system for agriculture in mountain / in plain / rice irrigation / other agricultural uses of water;
- Fresh water and fishing / related fixed and moveable equipment / know-how;
- Evidence of water uses for handicraft and industry / Water energy;
- Inland waterways, canals / related engineering / transportation by rivers and canals;
- Evidence of military uses of water for the defence system;
- Urban uses of water / water and city edification (pilot construction above water, boats as support of urban life: markets, etc.);
- Domestic use of water / fresh water and water quality;
- Water and wetlands, pounds etc. related to human wealth and diseases;
- Intangible values associated with water management and rivers / water related to traditions, symbols, beliefs, and religion; etc.

The proposed thematic study must, to offer a way forward to identify and describe water heritages, propose some pertinent examples. To this end, we have tried to draw up a typological inventory. This should primarily be seen as a methodological aid for anyone wishing to consider these questions, with a view either to achieving recognition and protection of such heritages by the World Heritage List, or to protecting heritage in a national or regional context.

We are fully aware of a dual challenge. First, water heritage is highly diffuse, and is present wherever mankind has settled, which gives rise to a real question when it comes to authenticating and analysing this specific heritage among other attributes. Second, a relatively large number of properties already inscribed on the World Heritage List have important hydraulic elements, which should be highlighted to a greater extent, particularly during the periodic revision or rewriting, if undertaken, of the Statement of Outstanding Universal Value.

Finally, in the context of this initial Thematic Study, the distinction between archaeological heritage and living heritage is essential. Archaeological heritages will of course be very well represented, as they are essential in a region whose proto-history and history are remarkable in every way. It is therefore important to establish a first appraisal of this heritage with care. However, living water heritages are a vital consideration for us, in a context in which water is rare catering to an increasing demand, particularly since the mid-twentieth century. With the development of modern technologies involving mechanical pumping, access to deep aquifers, and the use of new materials such as reinforced concrete, steel, etc., a form of negation, or ignorance, of ancient tangible and intangible water heritages has often prevailed. There have been many cases in which existing heritage has been abandoned or rebuilt radically, to the detriment of solutions which had demonstrated their sustainability. Our study of living heritages of water must take these questions on board to provide an overall appraisal, but this time not from the viewpoint of current systems, but from the viewpoint of heritage time, while considering them in the light of the challenges of the future. Our hypothesis is that today sustainable development should profit from the cultural heritage of water management, and that it is up to us to identify it and study it for everyone’s benefit.

For efficiency, the methodology of the presentation of this volume and the contributions of authors were undertaken along similar lines as the first study. The choice of the volume format was about delimitation of geographically concerned countries and/or regions. They are listed in the summary of the volume. For the articles, we first present a general overview of water management based on the heritage context for each country or for a large well-identified region, – and even for a very large water system at interregional scale such as the Grand Canal in China. Second, we present to the reader some precise case studies from a given region, based on a description and illustration of their attributes, then their exemplarity and/or originality for techniques, or their social management and representations.

Nevertheless, such a programme was ambitious and required time and human resources which we could not totally assemble. First, and to be frank, even with the help of ICOMOS National Committees, we sometimes faced notable difficulties in finding available authors with suitable competences in the field. Second, as everywhere, we faced the delicate situation of the COVID-19 pandemic situation for the implementation of the Thematic Study. This first caused difficulties in recruiting authors and second led to some delays or even some abandonment of articles. Many authors representing universities or cultural agencies or water management agencies faced more urgent and unexpected situations, requiring all their working time. So, we could not reach the complete expected set of articles initially expected for each country or geographical region. For some we have only one general overview, for others only some case studies, but every region is significantly represented by at least one article. We also used the important resources of already listed World Heritage properties, especially the documentation of the nomination dossier and the synthesis of the ICOMOS evaluation report as for the Grand Canal. Despite such difficulties, we have managed to maintain the programme and we expect that our readers will be satisfied with the result, as an introduction to a vast subject both for knowledge and methodology, which remains to be developed and completed together in the future.

Introduction

Les patrimoines culturels de l'eau dans les régions tropicales et subtropicales de l'Extrême-Orient et de l'Asie du Sud-est

Par Michel Cotte

L'ICOMOS a lancé dans les années 2010 une série d'études thématiques sur la gestion de l'eau en tant que patrimoine culturel, basées sur une approche régionale. La première région étudiée a donné lieu à un volume consacré aux « Patrimoines culturels de l'eau au Moyen-Orient et au Maghreb », dont une version initiale a été éditée en 2015. Une version révisée et augmentée a ensuite été publiée en 2017[5]. Dans l'introduction de cet ouvrage, nous avons décrit comment le nouveau thème patrimonial doit être compris, notamment dans l'esprit de la Convention du patrimoine mondial[6].

Les caractéristiques les plus importantes qui ressortent de cette étude concernent les pays arides et désertiques qui souffrent d'un manque d'eau permanent et qui ont besoin de dispositifs sophistiqués pour recueillir, conserver et gérer l'eau destinée au développement des communautés humaines. L'étude thématique a présenté un panorama impressionnant des capacités humaines mobilisées pour de telles pratiques et la démonstration de la longue durée de ces efforts. Elle a ensuite attiré l'attention sur le fait qu'au Moyen-Orient et au Maghreb, depuis l'époque ancienne de l'Islam jusqu'à la période moderne, la collecte et la gestion de l'eau ont occupé une place centrale. L'innovation, diffusée de pays en pays, parfois sous des noms différents, a atteint un niveau technique élevé et sophistiqué qui a permis le développement de la région. La culture de l'eau est donc un paramètre essentiel de la civilisation du Moyen-Orient et du Maghreb.

Avec cette étude, nous avions voulu éclairer et explorer une situation régionale en quelque sorte paradigmatique pour la gestion de l'eau en tant que patrimoine culturel. Deux raisons avaient attiré notre attention sur cette idée : d'abord l'unité et la continuité du contexte climatique, allant de zones arides à des zones semi-arides et méditerranéennes et, ensuite, l'unité de longue durée de la civilisation islamique entre tous ces pays; celle-ci fut particulièrement favorable à la diffusion des techniques, des connaissances scientifiques, des innovations et des bonnes pratiques. En outre, nous étions préoccupés par le manque d'attention pour ce type de patrimoine matériel du "quotidien", tant du point de vue des personnes que des administrations en charge du patrimoine. Il s'agissait pourtant d'un patrimoine humain évident et omniprésent faisant partie de la vie de tous les jours, au-delà de l'intérêt habituel manifesté pour le patrimoine culturel. Ces témoignages vernaculaires de notre passé, en apparence sans originalité et omniprésents, sont perçus comme des éléments purement pratiques, et non comme un patrimoine majeur et un leg précieux des temps passés.

Notre projet et notre publication ont rencontré un réel intérêt et une audience régionale, par exemple lors des Comités du patrimoine mondial de Doha (2014) et de Bahreïn (2018). Le Centre régional arabe pour le patrimoine mondial de Bahreïn (ARC-WH) a donné une visibilité particulière à cette étude thématique à travers une exposition publique et la traduction du volume en langue arabe[7]. L'un des résultats importants a été de nourrir l'intérêt de divers États parties de la région pour leur patrimoine de la gestion de l'eau, qui s'est exprimé par des projets, des études et des plans de protection. La

[5] *Michel Cotte (ed.), Les patrimoines culturels de l'eau au Moyen-Orient et au Maghreb, Paris, ICOMOS Etudes thématiques, 2015, édition révisée 2017. https://www.icomos.org/en/116-english-categories/resources/publications/3802-icomos-thematic-study-on-the-cultural-heritages-of-water-in-the-middle-east-and-the-maghreb*

[6] *Ibid., p. 9-24*

[7] *http://arcwh.org/fr/news/launch-of-arabic-version-of-the-thematic-study-the-cultural-heritage-of-water-in-the-middle east-and-the-maghreb*

publication a également contribué à élargir le spectre des thèmes du patrimoine mondial, comme le recommande la Stratégie globale pour une liste du patrimoine mondial représentative, équilibrée et credible[8]. L'objectif était enfin d'inviter les États parties à accorder plus d'attention aux attributs et aux significations de l'eau liés à des propositions d'inscription importantes et complexes, comme c'est le cas pour les centres historiques ou les paysages culturels.

Cette nouvelle étude thématique fait suite à une importante réflexion et à de multiples actions au niveau international, notamment sous l'égide des différentes agences de l'ONU, de l'UNESCO, et d'ONG spécialisées à l'expertise reconnue. L'action de ces organisations est guidée par le souci de favoriser un développement plus durable des sociétés humaines, et notamment de contribuer à la maîtrise des facteurs techniques, sociaux et culturels liés à l'accès et à l'utilisation de l'eau. Dans ce contexte, une meilleure connaissance et compréhension des patrimoines culturels traditionnels liés à l'eau apparaît nécessaire et utile.

L'objectif initial de l'approche que nous adoptons ici est de contribuer à la reconnaissance, à l'étude et à la préservation de ce type de patrimoine. De ce point de vue, le cadre fourni par la Convention du patrimoine mondial forme un outil important, donnant des indications pertinentes. Il peut sans doute jouer un rôle encore plus important à travers la méthodologie qu'il fournit pour l'identification et ensuite la préservation de ces patrimoines, dans un contexte plus large, par exemple pour les biens d'importance régionale ou locale. Il convient ici d'établir une distinction entre les patrimoines vivants, qui sont encore activement utilisés par les communautés humaines, et les patrimoines archéologiques ou les paysages reliques qui témoignent des sociétés du passé. Enfin, un patrimoine international de l'eau bien identifié, et dont la valeur réelle est reconnue, peut constituer un thésaurus de solutions techniques durables dont les coûts matériels, sociaux et énergétiques sont raisonnables par rapport aux réponses extrêmes de la technoscience contemporaine appliquée au domaine de l'eau.

L'eau occupe une place particulière parmi les nombreuses relations qui existent entre l'homme et la nature. Elle répond à un besoin humain permanent et essentiel. L'accès à l'eau est un élément vital commun à toutes les civilisations humaines; il n'y a pas d'exception, et toutes les civilisations ont une culture de l'eau. Les sociétés tentent de maîtriser durablement cette relation de dépendance qui se manifeste dans toutes ses composantes. L'eau est une condition indispensable à la survie des sociétés humaines et l'on sait que, si elles n'y parviennent pas, leur avenir sera compromis, à moyen et long terme.

Il convient de distinguer les eaux douces des eaux salées. Nous avions limité le champ patrimonial considéré aux eaux douces et aux eaux continentales. L'eau répond à des besoins individuels et collectifs essentiels, mais ces besoins sont en constante évolution, du fait de la démographie des sociétés et de l'évolution des usages dans les nombreux domaines de l'activité humaine. Les besoins peuvent être directs (alimentation, hygiène, etc.) ou indirects (agriculture, industrie, énergie, transport, etc.). De plus, l'eau, en tant que matière première, n'est que rarement un produit pur, car elle contient des sels minéraux et souvent des polluants importants et variés.

Toute civilisation produit des équipements matériels et des règles sociales destinés à garantir la satisfaction des nombreux besoins décrits ci-dessus. Elle doit également être capable de faire face à l'évolution et aux changements des paramètres des ressources en eau. Les civilisations produisent les facteurs techniques et l'organisation collective qui sont liés à la gestion et aux usages de l'eau. Chacune a produit une culture de l'eau que nous pouvons connaitre à partir des patrimoines dont nous avons hérité, sous forme de vestiges vivants ou archéologiques, dont les composantes sont directement liées aux données hydrologiques et climatiques régionales et locales.

Les pays tropicaux et subtropicaux de l'Asie de l'Est et du Sud-Est ont retenu notre attention pour

[8] *Orientations devant guider la mise en œuvre de la Convention du patrimoine mondial, Paris, UNESCO, §54-61*

poursuivre le travail de l'ICOMOS sur la gestion de l'eau en tant que patrimoine culturel, par le biais de cette nouvelle étude. Il s'agit d'une région du monde avec des caractéristiques communes bien identifiées et fortes, tant pour ses conditions climatiques que pour le partage de valeurs culturelles communes, telles que le phénomène de la mousson, la "civilisation du riz", les influences historiques de religions partagées comme le bouddhisme, les influences et échanges mutuels à travers l'histoire, les pratiques techniques pour la construction et les arts, etc.

Il s'agit d'un contexte régional intrinsèquement différent de celui des régions arides et semi-arides du Moyen-Orient et du Maghreb, mais nous poursuivons le même objectif général d'identification et de compréhension patrimoniale. Les périodes de mousson et les saisons les moins humides peuvent varier d'une sub-région géographique à une autre, de même que varient les modes de gestion de l'eau pratiqués par les diverses civilisations. Bien sûr, il est difficile de définir clairement les limites de cette nouvelle étude thématique, surtout dans le contexte de l'Asie du Sud-Est, où les conditions géo-climatiques et les contacts culturels au cours de l'histoire sont importants avec l'Asie du Sud et avec les archipels de l'Océan Indien situés à proximité. Un futur volume sera consacré à cette partie sud de l'Asie, région typiquement tropicale. Nous avons décidé de limiter ici notre approche afin que ce volume puisse rester suffisamment cohérent pour les lecteurs.

L'irrigation apparaît comme une caractéristique technique et culturelle de base de cette région tropicale. Certains systèmes hydrauliques sont exceptionnellement grands, anciens et techniquement impressionnants. La variété et la subtilité de l'irrigation, équilibrées par un drainage efficace, sont essentielles pour gérer à la fois la pénurie et l'excès d'eau sur les terres. Pour toutes ces raisons, cette région doit être étudiée pour elle-même et avec soin. Elle propose des exemples spécifiques découlant des choix sur le captage de l'eau, sur son transport, sur sa régulation avec des dispositifs à grande échelle, également pour la lutte contre les inondations. Il résulte de tout cela un génie civil et hydraulique parfois très impressionnant. D'autres utilisations de l'eau ont donné lieu à des initiatives importantes pour le transport terrestre par les canaux, la défense militaire, etc.

Les rivières elles-mêmes doivent être considérées comme un patrimoine important, à la fois naturel et culturel, pour leurs fonctions économiques et sociales majeures, par exemple pour l'urbanisme des bateaux, pour les cérémonies religieuses et symboliques, etc. Il devrait en être de même pour les sources d'eau douce, ou certaines zones humides. L'ethnographie des usages de l'eau, s'appuyant sur des valeurs naturelles et culturelles, devrait être porteuse de significations immatérielles importantes. L'éventail des exemples techniques et la diversité des significations seront plus vastes que ce que nous pouvions imaginer au début du projet.

Découlant de ce programme, et en relation avec la région définie, avec ses conditions géo-climatiques et son histoire, les thèmes majeurs couverts par ce volume sont, en résumé, les suivants :

- *Captage d'eau et réseaux d'approvisionnement à l'échelle locale-moyenne / ingénierie hydraulique et gestion hydraulique associées / caractéristiques immatérielles associées;*
- *Réservoirs d'eau et contrôle de l'eau / réseaux d'approvisionnement en eau à grande échelle / ingénierie associée et valeur immatérielle associée;*
- *Contrôle des crues des rivières / digues et régulation des eaux;*
- *Système d'eau pour l'agriculture en montagne / en plaine / irrigation du riz / autres utilisations agricoles de l'eau;*
- *Eau douce et pêche / équipements fixes et mobiles connexes / savoir-faire;*
- *Témoignages des utilisations de l'eau pour l'artisanat et l'industrie / énergie hydraulique;*

- *Voies navigables intérieures, canaux / ingénierie connexe / transport par les rivières et les canaux;*

- *Preuve des utilisations militaires de l'eau pour les systèmes de défense;*

- *Usages urbains de l'eau / eau et édification de la ville (construction sur pilotis au-dessus de l'eau, bateaux comme support de la vie urbaine : marchés, etc.);*

- *L'utilisation domestique de l'eau / l'eau douce, la qualité de l'eau;*

- *L'eau des marais, des étangs, etc. et les conditions sanitaires liées à l'eau;*

- *Valeurs immatérielles associées à la gestion de l'eau et aux rivières / l'eau liée aux traditions, aux symboles, aux croyances et à la religion; etc.*

L'étude thématique proposée doit, pour permettre d'identifier et de décrire les patrimoines de l'eau, présenter des exemples pertinents. Pour cela, nous avons tenté de dresser un inventaire typologique. Il doit être considéré avant tout comme une aide méthodologique pour toute personne souhaitant se pencher sur ces questions, en vue soit d'obtenir la reconnaissance et la protection de ces patrimoines par la Liste du patrimoine mondial, soit de les protéger dans un contexte national ou régional.

Nous sommes pleinement conscients d'un double défi. D'abord, le patrimoine de l'eau est très diffus, il est présent partout où l'Homme s'est installé, ce qui pose une réelle question lorsqu'il s'agit d'authentifier et d'analyser ce patrimoine spécifique parmi d'autres attributs. Deuxièmement, un nombre relativement important de biens déjà inscrits sur la Liste du patrimoine mondial présentent des éléments hydrauliques importants, qui devraient être davantage mis en valeur, notamment lors de la révision périodique ou de la réécriture, si elle est entreprise, de la déclaration de valeur universelle exceptionnelle.

Enfin, la distinction entre patrimoine archéologique et patrimoine vivant est essentielle. Les patrimoines archéologiques seront bien sûr très représentés, car ils sont essentiels dans une région dont la protohistoire et l'histoire sont en tous points remarquables. Il est donc important d'établir avec soin un premier bilan de ce patrimoine. Cependant, les patrimoines d'eau vivante sont pour nous une considération essentielle, dans un contexte où l'eau utile devient rare pour répondre à une demande croissante, notamment depuis le milieu du XXe siècle. Avec le développement des technologies modernes impliquant le pompage mécanique, l'accès aux aquifères profonds et l'utilisation de nouveaux matériaux tels que le béton armé, l'acier, etc., une forme de négation, ou d'ignorance, des anciens patrimoines matériels et immatériels de l'eau a souvent prévalu. Dans de nombreux cas, le patrimoine existant a été abandonné ou reconstruit de manière radicale, au détriment de solutions qui avaient pourtant démontré leur durabilité. Notre étude des patrimoines vivants de l'eau doit s'emparer de ces questions pour en dresser un bilan global, mais cette fois-ci non pas du point de vue des systèmes actuels, mais du point de vue du temps des patrimoines, tout en les considérant à la lumière des enjeux du futur. Notre hypothèse est qu'aujourd'hui le développement durable doit profiter du patrimoine culturel de la gestion de l'eau, et qu'il nous appartient de l'identifier et de l'étudier pour le bénéfice de tous.

Par souci d'efficacité, la méthodologie de présentation de ce volume et les contributions des auteurs ont été entreprises dans la lignée de la première étude. Le choix du format a porté sur la délimitation des pays et des régions géographiquement concernés. Le sommaire du volume en donne la liste. Pour les articles, nous présentons d'abord une vue d'ensemble de la gestion de l'eau basée sur le contexte patrimonial propre à chaque pays ou grande région bien identifiée, - et même à un très grand système d'eau à l'échelle interrégionale tel que le Grand Canal en Chine. Dans un second temps, nous présentons au lecteur quelques études de cas précises d'une région donnée, basées sur une *description et une illustration de leurs attributs, puis de leur exemplarité et/ou originalité quant aux techniques, ou encore de leur gestion sociale et de leurs représentations.*

Néanmoins, un tel programme était ambitieux et demandait du temps et des ressources humaines que nous ne pouvions pas totalement réunir. Tout d'abord, et pour être franc, même avec l'aide des comités nationaux de l'ICOMOS, nous avons parfois rencontré des difficultés notables pour identifier des auteurs disponibles et compétents dans le domaine. Deuxièmement, comme partout, nous avons fait face, pour la mise en œuvre de cette étude thématique à une situation contextuelle pandémique délicate, source d'abord de difficultés pour le recrutement des auteurs et ensuite de retards, voire d'abandons d'articles. De nombreux auteurs représentant des universités, des agences culturelles ou des agences de gestion de l'eau ont été confrontés à des situations plus urgentes et inattendues, absorbant tout leur temps de travail. Ainsi, nous n'avons pas pu obtenir l'ensemble des articles espérés pour chaque pays ou région géographique. Pour certains, nous n'avons qu'une vue d'ensemble, pour d'autres, seulement quelques études de cas, mais chaque région est présente de manière significative à travers au moins un article. Nous avons également utilisé les ressources importantes des biens déjà inscrits au Patrimoine mondial, en particulier la documentation du dossier de candidature et la synthèse du rapport d'évaluation de l'ICOMOS comme pour le Grand Canal. Au-delà de ces difficultés, nous avons maintenu le programme et nous espérons que le résultat pourra satisfaire le lecteur, en tant qu'introduction à un vaste sujet, tant pour la connaissance que pour la méthodologie, que nous devrons développer et compléter ensemble à l'avenir.

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2. South Korea

Regional overview: Water and heritage on Jejudo Island: An evolutionary process in the conservation and use of spring water

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1. General characteristics of Jejudo Island

1.1. General description of geological and hydrological conditions

At first glance, Jejudo Island differs from the islands of the south coast borderland in Korea in terms of size, elevation and its rounded outline. This appears as an ellipse, whose axes are 76 and 32 km long, spanning an area of 1,859 sq.km. Rising out of shallow sea, which seldom reaches a depth of 130 m, this rises up to 1,950 m that marks the summit of Hallasan Mountain. Overall, the island forms a shield whose surface rises from all sides with concave profile lines toward the central bulge of the massif that forms its core. The steep-sloped central massif, with its centre at Hallasan, occupies approximately one-fifth of the total area. The other half, sloping gently from the central massif toward the coast, remains densely forested to date. The remaining parts on the flat coast are dominated by meadows and fields.

Jejudo consists almost entirely of recent volcanic flows, which are largely responsible for its surface forms, specifically the Late Pleistocene basalt lavas, which represent the third eruption series. The Hallasan basalt covers almost half of the island and because of such highly permeable geological structures, surface waters are rare. Almost all types of lavas have a columnar structure and are therefore highly permeable, and, consequently, with dry surfaces. Streams and creeks tend to flow downwards in a radial pattern along the slopes of Hallasan Mountain, with larger streams seen mainly along the northern and southern slopes. The jumbled gravel beds of the streams and creeks, filled with giant boulders, are generally dry except during the rainy season.

The annual precipitation on the island is 1,975 mm, the highest rainfall in Korea, but despite this there are no perennial streams. Water flows in the stream channel only during the rains. In general, once the rainfall on the central massif penetrates the groundwater, it continues to flow downwards until it springs up above ground on the coast. Therefore, a source of drinking water could only be found on the coast before modern water-supply systems for extracting groundwater were introduced. Spring water, or *sanmul* and rainwater, or *boncheonsu* on the ground were the main sources for drinkable water in the past. Today, it is no longer a problem to obtain drinkable water. This has promoted a modern water-based industry to develop commercial products such as bottled water, beverages, alcoholic drinks, and even water-therapy services through the exploitation of the clean and abundant groundwater.

1.2. General climatic and vegetational data

Since Jejudo Island is an outpost of the Korean peninsula reaching far southward into the warm sea, it has a subtropical climate and not the continental climate found elsewhere in the country. The southern coast and islands on the South Sea, away from the southern coast, by contrast, lie somewhat between temperate and subtropical zones. The 'land monsoon' in winter often warms up the Korea Strait, through which a branch of the Kuroshio flows. The mean January temperatures in this area are thus the highest in Korea. Jejudo is the only part of the Korean peninsula in which the average minimum temperatures during winter months do not drop below freezing point. The 'sea monsoon' in summer increases the temperature and humidity on the island. As summer is the main period of precipitation, the rains are brought by the sea monsoon itself more than by cyclones. In autumn, typhoons in the vicinity of the island are responsible for the rainfall.

Jejudo is characterised by an extremely impressive altitudinal classification of vegetation across three main altitudinal zones: subtropical, temperate and subalpine ones. These are separated approximately by contours: 200m, 600m, 1600m. The region belonging to the subtropical zone, below 600m (above mean sea level), is used for intensive agriculture and grazing. In the upper subtropical zone, between 200m and 600m, evergreen species, such as camellia, grow rampantly as shrubs and small trees, and summer-green woody plants predominate. The pastures that characterise the upper subtropical zone extend indiscriminately across the lava plains and the parasitic cones. The lower subtropical zone, below 200 m comprises largely of cultivatable fields where the porous lavas are covered by a brown soil and densely scattered un-weathered blocks.

2. Significant sites for the cultural heritage of water

Until the modern water-supply system was introduced in the 1980s, spring water was the main source of water for the residents of Jejudo Island. It supplied not only drinking water but also catered for domestic and agricultural use. Therefore, most villages were located along the coastal zone where spring water could be easily found. This is an important indicator that availability of spring water was responsible for the location and growth of settlements on the island.

2.1. Distribution of spring sites

Sites of natural springs are distributed widely throughout the island, but with the heaviest concentration on the coast. Their locations vary from the lowest elevation on the coast to the highest one at the base of Hallasan. This extensive distribution of natural springs is the result of high precipitation on terrain that has a geological structure with multiple layers of lava and volcaniclastics. According to a comprehensive survey (2013–2014) carried out by the Jejudo provincial government, 1,013 sources of spring waters once existed. If those which had been buried or lost are excluded from this list, the remaining 661 sites can be identified. Of these, those located on the coastal zone (200 m above sea level) comprise 600 sites (90.7 per cent), 36 sites (5.5 per cent) are located on the intermediate mountain zone (200-600 m above sea level) and those on the mountain zone (higher than 600 m) account for 25 sites (3.8 per cent). (Fig. 1).

Depending on the physical terrain on Jejudo Island springs can be classified as (1) the lava-flow boundary type, (2) the joint type, or (3) the sand-gravel layer type. These classifications reflect the geological features at the discharge point of spring water. The lava-flow boundary type are the springs that emerge along the boundary of lava flows. The joint type is the one that emerges from crevices or rock fractures. The sand-gravel layer type is the one that flows from unconsolidated or semi-consolidated sand-gravel layers usually associated with a topographic sink or abrupt change in

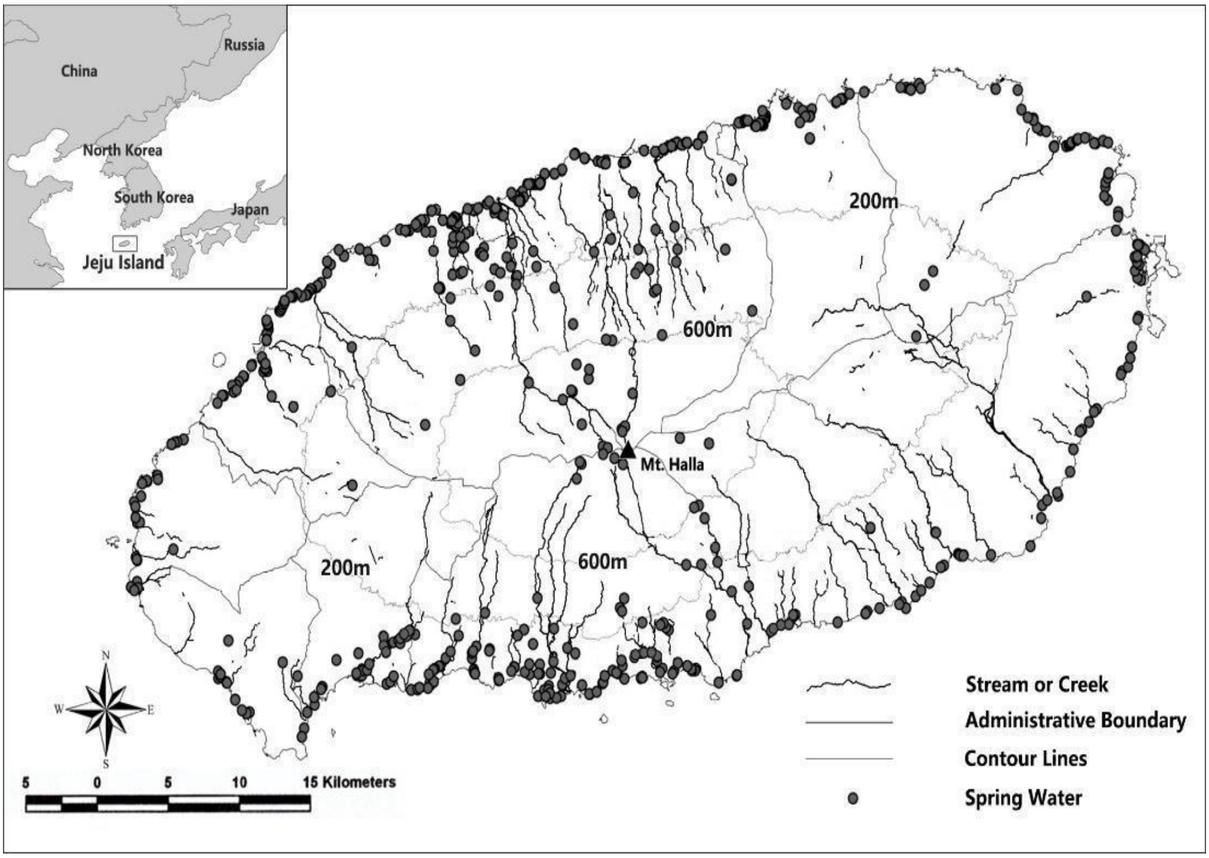

Fig. 1: Distribution pattern of springs on Jejudo Island (2013–2014).

elevation. The lava-flow boundary type is the most common (90.3 per cent). These lava-flow boundary sites are densely distributed along the coast because groundwater flows down from Hallasan Mountain toward the coast where the lava flows have terminated. The joint type and sand-gravel layer type, respectively, represent 7.4 percent and 2.2 percent of the total number on the island. In addition, locations of springs are closely related to topography. The springs are located on cliffs or bluffs, at sunken spots in uneven land surfaces, and at the foot of a mountain. Trachytic lavas can make uneven topography favourable for the occurrence of springs because the viscosity of these lavas is higher than that of basaltic lavas. Therefore, springs on the island are generally more common in trachytic rocks than in basaltic rocks.

2.2. Archaeological sites

2.2.1. Gusimul

This spring site has a significant cultural association. A special band within the army called *Sambeoylcho* once used this when it founded a military base in the castle called *Hangpaduri* for organising the resistance against the Mongol invasion (1271–1273) in the late Goryeo Dynasty. The site continues in the same location outside the walls as in the past. (Fig. 2). At that time outer walls were constructed to protect it even though it was located outside the inner walls. It is said that soldiers and residents used to drink this spring water during the military campaign against the Mongol army. Later the water was supplied to the paddy field below it to be used for irrigation. A conduit called *gusi*, that still exists, was artificially made to transport the water from the spring to the paddy field below (Figs. 4–8). The water was considered of such high quality that those who drank it during the spread of cholera were believed to be free from the epidemic. The body of spring water was surrounded by stone walls for protection, being divided into three tubs: one for drinking and two for washing clothes (Figs. 4–8).

An open entrance and conduit were arranged at one side of the walls so that the water could flow downwards from the source (Figs. 4–8). The whole property around the spring water has been well preserved along with the area of the *Hangpaduri Castle* which was designated as a national level historic site.

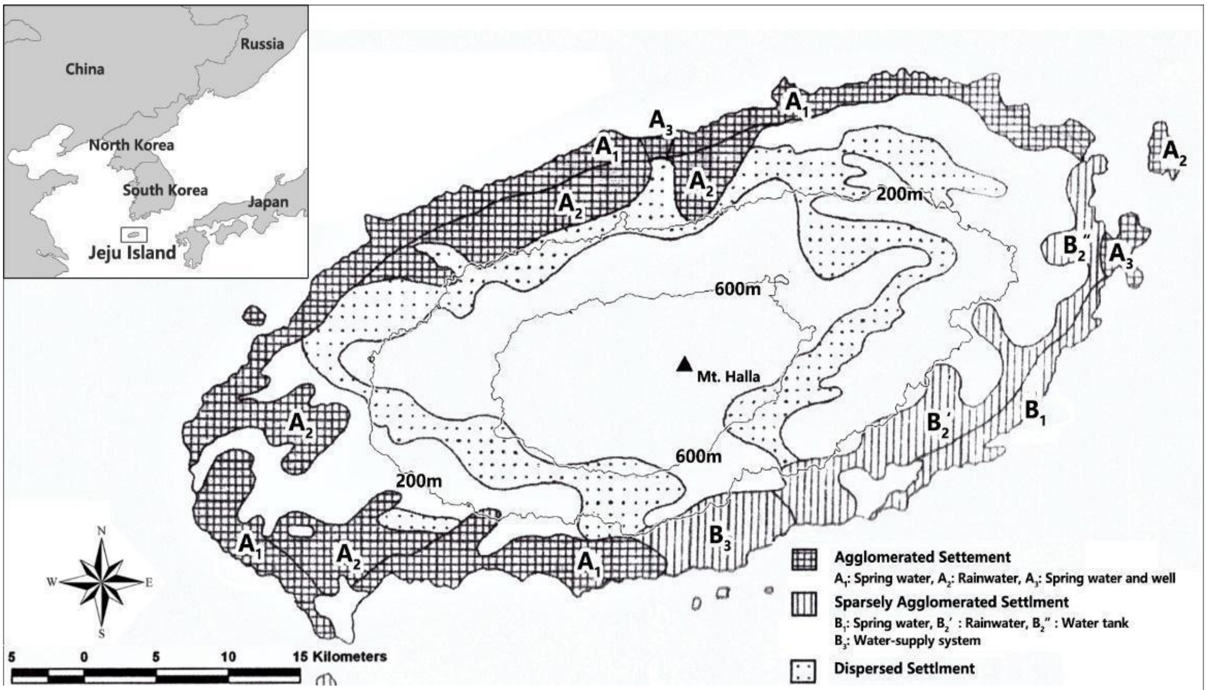

Fig. 2: The pattern of water use and settlement morphology in the 1930s.

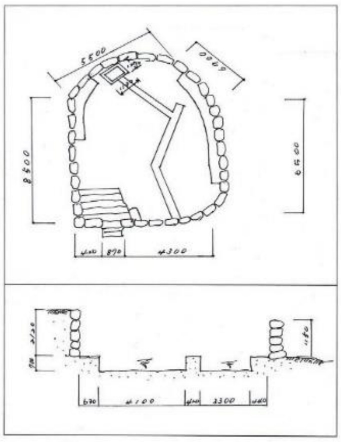

Fig. 3: Plan of Gusimul.

Fig. 4: Gusimul.

Figs. 5-6: Gusimul.

Figs. 7–8: Gusimul.

2.2.2. Ongseongmul

Fig. 10: Ongseongmul.

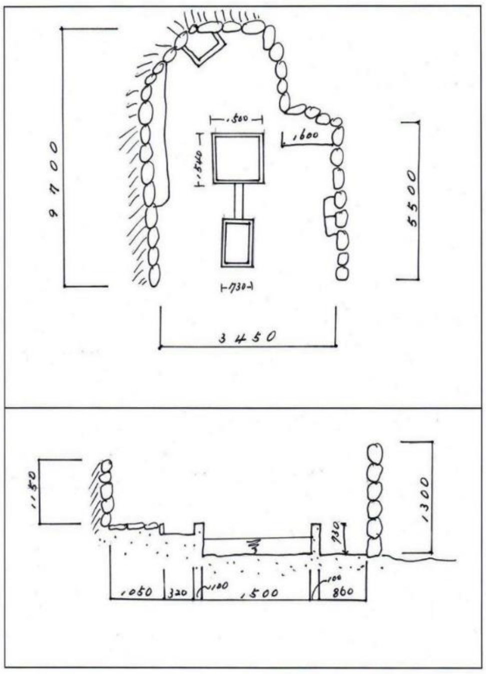

Fig. 9: Plan of Onseongmul.

According to oral tradition, during the military campaign by *Sambeoylcho*, this spring water was used by military officers, including General Tong-Jeong Kim. It was not for the soldiers and residents, who had to drink the other spring water, called *Gusimul***.** This implies that at that time spring waters were classified into different categories corresponding to social hierarchy. General Tong-Jeong Kim (?–1273) of the rebellious army *Sambyeolcho* had succeeded General Jung-Son Bae (?–1271), the first leader. The body of spring water like the previous example was surrounded by stone walls and divided spatially into three tubs along the channel from the discharge point of water at the top to the outlet below **(**Fig. 10**).** It is now located inside a Buddhist temple called *Geukraksa*, which is rarely used. It is said that it was originally used by residents for their personal prayers at home reiterating its sacred significance.

2.2.3. Sowangmul

Fig. 12: Sowangmul.

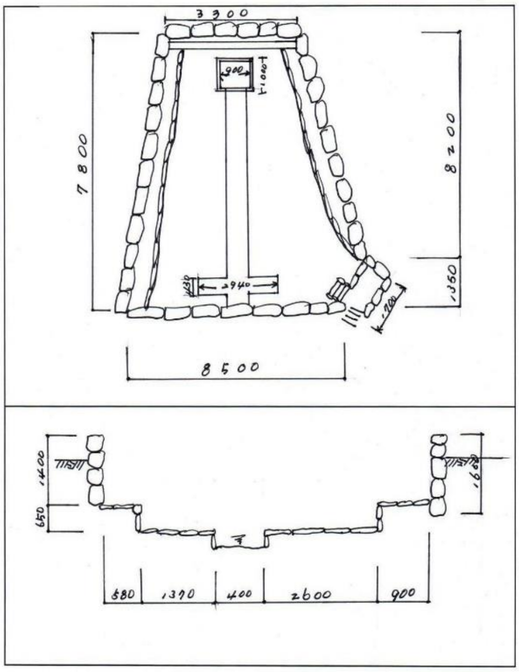

Fig. 11: Plan of Sowangmul.

An oral tradition indicates that Sowangmul served as the main source of water around which a village could grow after the first settlement was established by one man, whose family name was Go, 750 years ago. It is one of the few sites which has maintained its historic condition in terms of form, material, and spatial arrangement (Figs. 12–14). Many spring sites on Jeju Island were repaired with modern materials like cement during the Japanese occupation (1919–1945) and even after the liberation, but this was an exception. As its tubs and surrounding walls were constructed of natural stones which were available nearby, it represents a relatively high heritage value. This site is a testimony to the ancient method of piling natural stones that has been handed down from generation to generation. It is a traditional method, unique to the island wherein the stone blocks were tightly laid with no gaps during the construction of the dry-stone walls. The tubs were constructed with large stones artificially carved in the same way as was done for the construction of walls. The shelves called *Mulpang*, upon which women came and placed their carriers called *Mulgudeok*, every day and night, were made of flat, long stones on one side near the tubs (Figs. 12–14). Depending on use, from the discharge point of water above to the outlet below, the body of spring water was spatially divided into four tubs: drinking, washing vegetables, doing laundry, and bathing and so on.

Fig. 13: Sowangmul.

Fig. 14: Sowangmul.

2.3 Living sites

2.3.1 Yusuamcheon

It is said that this spring water was discovered and exploited by a Buddhist monk who had followed General Tong-Jeong Kim and his army *Sambyeolcho* and settled down near the castle *Hangpaduri*. He erected a temple sometime after 1271 around which General Kim's family and its servants located their residences while using the spring water called Yusuamcheon. Compared to the archaeological sites mentioned above, this represents a living site, still in use, being located on the intermediate mountain zone at an elevation of between 200 m and 600 m (above mean sea level). It is famous for its abundant spring water, and is still suitable as a source of drinking water for local residents. The body of spring water was divided spatially into two tubs: one larger and the other smaller (Figs. 15 & 16). The smaller one above was to be tapped for drinkable water, and the larger one below is arranged to function as a water tank to be used in case of water shortage during the dry season. The body of spring water is surrounded by stone walls with an open entrance on one side. In addition, a secondary water tank was located about 29 m away from the primary water tank. The water flows downwards from the primary water tank into the secondary one through an artificial conduit. This one was divided spatially into three tubs, which were only intended to be used for washing clothes. Further below it, a pond was made to receive the water that had been used in the secondary water tank, with the final purpose to supply drinkable waters to cows and horses.

Fig. 15: Yusuamcheon.

Fig. 16: Yusuamcheon.

2.3.2. Saetdorimul

In the 1980s, in the area around a coastal inlet called *Samyangpogu*, three modern reservoirs were constructed on the existing sites of natural springs. Though the construction may have reduced the quantity of the spring, fresh waters still spring up along the coast, from the bottom of the sea as well as above ground. People come and watch with enjoyment this special phenomenon where fresh waters spring up through the surface of the sea. Around the coastal inlet, fresh waters spring above the ground in five locations to make a row from east to west, forming an arc: Namjamul, Keunmul, Doktongmul, Saetdorimul and Eongdeokmul. Among them Saetdorimul was believed to be so sacred as to be used for a special kind of shaman performance to expel evil spirits. (Fig. 2). On Jejudo Island, it was a tradition that shamans should drive birds away when they began their performance called *gut*. To drive birds away was thought to be equal to expelling the evil spirit. Alongside driving the birds away, shamans spread the clean water drawn from Saetdorimul onto the ground with the belief that such a performance could purify its contaminated condition and finally expel the evil spirit. On the island, a crow was traditionally believed to be an ominous bird that carried an evil spirit. Residents preferred to drink the water from Saetdorimul with the belief that it was not only protected as sacred water but also clean. Today, however, it is no longer considered to be sacred or used for drinking, rather it is only used for washing clothes and for playing in.

2.3.3. Keunmul

Six sites of spring waters are distributed around the coastal inlet called Shinchonripogu: Jobanmul, Jogeunmul, Keunmul, Malmul, Eongchangmul and Gameonmul. The body of Jobanmul is divided spatially into two tubs: outer and inner. The outer one, visible from outside, was designed to be used for drinking water and washing vegetables. The inner one was blocked by stone walls not to be seen from outside and divided into two tubs: one for washing clothes and the other for bathing by women only. At the entrance to Jobanmul, is located a smaller water pool called Jogeunmul, to be used for bathing by men only. Of these spring waters only two remain to be used for human use: Keunmul and Malmul. Keunmul was originally the main source of drinking water used by residents around the coastal inlet called Shinchonripogu. Located in the coastal lowland, this maintains a freshwater status to be drinkable at the time of the ebbing tide, but during high tide it is mixed with saline water and thus not drinkable. It was called Keunmul, literally meaning 'large water', because it had the highest quantity of spring water around the coastal inlet, surviving even the dry season. It is divided spatially into two tubs: one for drinking water and the other for washing clothes. It is also surrounded by stone walls to block the view from outside, with an entrance to which only women had access. Women believed that to bathe here would maintain their health and ensure longevity. Next to this one, emerges a spring called Malmul whose quality was not good enough to be drinkable. Being surrounded by stone walls, it was designated for cows and horses. At present, however, Keunmul is no longer used for drinking water, it is used for washing clothes and for bathing by women. Malmul is also no longer used for drinking water by cows and horses, as originally intended, but for bathing only by men.

2.4. A Cultural landscape related to water: Yongdamdong around a coastal inlet

Two large streams – Byeongmunnae and Hannae – originate in Hallasan Mountain and flow through the administrative village called Yongdamdong. It is divided by a stream called Hannae into two natural villages: Seohandugi on the western side and Donghandugi on the eastern side. Further west along the coast, lies another natural village: Dakkeunae. The stream called Byeongmunnae is usually without water upstream but filled with water from springs near the coast. The stream called Hannae is also dry upstream, but, with the flow of water near the inlet, it makes a relatively deep natural pond. The local residents call it Yongsu, literally meaning Dragon's Pond.

Around this pond are located two main springs which residents preferred to use: Tongmul and Meogunangmul. In the village of Seohandugi, a dual structure of stone walls was constructed to a height of 1.5 m as a castle to enclose the spring water of Tongmul. Its width was designed to prevent sea water from penetrating into the spring water. A hole was made beneath on one side of the stone wall to enable sea water to flow back into the sea if it penetrated the spring water. The body of spring water was divided spatially into two tubs: one for drinking water, and the other for washing clothes and bodies. It had the reputation that fresh water always sprang even in high tide, and thus attracted villagers from nearby settlements to tap it during the dry season. In the past, it meant that a village with good spring water was also favourable to live in, and that is why the inhabitants were proud of Seohandugi.

By contrast, the residents in Seohandugi did not need to tap the spring waters in other villages. A water community, which shared the same spring waters, served as the social and physical foundation for the organisation of a village community. The territorial boundary of a village community roughly corresponded with that of a water community. In general, everyone in a village tended to assume that spring waters in their village were the cleanest, in comparison to others. The inhabitants took pride in living in proximity to clean and drinkable spring waters.

In general, residents of coastal villages below 200 m (above mean sea level) did not rely on other villages for their drinking water except in time of severe water shortage, which was a rare occurrence. On the contrary, communities residing in the intermediate mountain zone (200-600 m above mean sea level) frequently depended on villages on the coastal zone for their drinking water. As a result, social networks between coastal villages were few with stronger interactions between the coastal and the intermediate mountain zone. Donghandugi and Seohandugi though located in geographical proximity were socially distant because they used spring waters within their own village territories. Furthermore, each of these villages maintained close social relations with their neighbouring villages on the intermediate mountain zone through sharing of spring waters. In return, the inhabitants of the intermediate mountain zone contributed the expenses and labour required for the repair of facilities related to the spring. Households in the villages on the intermediate mountain zone were vulnerable to water shortage during the dry season. They received their drinking water by tapping, collecting and protecting rainwater in jars and pools.

3. Existing documentation

3.1 Inventories of cultural heritage of water

A comprehensive survey (2013–2014) identified 661 sites that had escaped from burial and destruction resulting from neglect and development. The document confirmed that 1,013 sites had originally existed, subsequently, 270 sites were buried and destroyed, and 364 sites were left unused. The remaining 448 sites in disuse comprise 67.8 per cent of the total number (661 sites) of sites whose location was identified. It was estimated that 200 sites are still in use, though rarely for drinking purposes, while 441 sites have already been abandoned without use. Of these 200, 32 sites were found still in use for drinking, and 147 sites for washing clothes and bodies, and 21 sites for agriculture.

In 2014 Jejudo Province issued the ‘By-Law for the conservation of Spring Water in Jeju Province.’ According to this By-Law, a conservation plan was required to be prepared for the spring waters that were to be considered for special conservation. The conservation values were to be assessed as per the following six standards: historical and cultural value; accessibility; quantity of spring water; water quality; degree of use by residents; state of conservation and management. Historical and cultural value is closely associated with cultural heritage. This criterion is further described based on: the existence of historical documents and monumental scale which are a testimony to the exploitation of the springs; trustworthy records related to oral traditions such as legends, mythology and folk literature, in the context of these sites; identification of tangible elements that represent the historicity of the site in the absence of records.

3.2. Archive documents and collection of photographs

The descriptions on how Indigenous people on Jejudo Island obtained their drinkable water, difficult to locate during the Joseon Dynasty, can be found partly in the old royal documents, such as Singeojiseungram, Tamlarok from Joseonwanjosilrok, Tamlaji, Namcheonlok, and Jejupungtorok and others. For example, a travelogue called Namchenorok (**南遷錄)**(Seonggu Kim, 1679) identifies that the main sources for drinking water on Jejudo Island were spring water, rainwater and running water in streams. This mentioned that: 'People think that any site of spring water, within a distance of 2.5 km from their home, is close enough to go and tap for drinkable water. The water tastes too salty to drink, but they have been already used to it without feeling any pain drinking it.'

In addition, a chronological record called Namhwannakmul (**南宦博物)** (Hyeongsan Yi, 1704) states that: 'There are very few good spring waters on Jejudo Island.... People think that any site of spring water, within the distance of 2.5 km from their home, is close enough to come and carry back home to be used for drinkable water. At the worst, people could not but make round trips to the spring sites, even more than 10 km away from their home, to fetch drinkable water home for their families. The water tastes too salty to drink without pain, but local people do not know-how painful it is because they are so accustomed to it. Those from outside the island will easily get sick from it after they feel nausea, and finally vomit it if they drink the spring water'.

Books and public reports, written by Japanese scholars and officials record how indigenous people on Jejudo Island found and used drinkable water during the Japanese occupation (1910–1945). A book written by a Japanese geographer, presents a detailed description on the association of location and growth of rural settlements with the location of water sources. According to his survey based on field observation, the sources of drinkable water were classified into five types: spring water; rainwater; spring water and well; water tank; modern water-supply system. The use of spring water is relatively ubiquitous across settlements on the island, being dominant in the zone of agglomerated settlement, which had evolved mainly along the coast. By contrast, the use of rainwater was dominant in the zone of sparsely agglomerated settlement concentrated in the intermediate mountain zone. In addition, monumental steles were erected in commemoration of historical events or as a personal dedication in the introduction of modern type of water-supply system.

3.3. Conclusion

The culture in relation to the use of water, unique to Jejudo Island, has gradually disappeared under the influence of a Western way of life after completion of the modern water-supply system in the 1980s. The historic perspective was characterised largely by the wisdom on how to save and consume water while viewing it as a public resource to share. Remnants of tangible heritage such as water tubs and their surrounding walls of historic value have been either modified or destroyed. Historical records, including public documents are lost mainly due to the ignorance of heritage values that testify the conditions of the past. A series of projects to collect and record oral traditions documenting and interpreting intangible heritage, especially related to the life of women, have been undertaken only recently.

The history and culture of Jejudo Island cannot be separated from the history and culture related to the spring waters. Therefore it is imminent to explore further data sources, either written or oral, in order to study the historical and cultural aspect of spring water in more detail as follows: The relationship between spring water and the origin of settlement, between spring water and agriculture (and husbandry), between spring water and belief systems (and rituals), between spring water and medical treatment, between spring water and the village ethical code, between spring water and tradition (and custom) and its impact on the exploitation and maintenance, and between spring water and tradition (and custom) and its impact on protection. The most imminent is the survey to collect and compile historical data concerning the springs which were used as sources of drinking water.

4. State of historic and technical knowledge concerning water heritage

4.1. Periodisation of man's relationship with water

On Jejudo Island, water had been a scarce resource until the 1970s when underground water began to be actively exploited. Spring water from the ground offered the only source of drinkable water for local residents on the coastal zone. Women were the main players in the evolution of culture related to the use of spring water. Tangible and intangible aspects of such a culture include the means of carrying home and storing drinkable water, tasks exclusively carried out by women: *mulheobeok*, the carrier in the form of a jar, *mulgudeok*, the bamboo-made cover for *mulheobeok*, and *mulpang*, or stone-shelf on which to place *mulheobeok***.** Only women were responsible for carrying home and storing the drinkable water which they had drawn from the spring. It is, moreover, women who were mainly responsible for the management of the spring, including maintaining sanitary conditions through regular cleaning. Men were not allowed to enter the space of the main source of drinkable water, a space reserved exclusively for women.

From 1953 this tradition began to gradually change, and this sacrificial role played by women subsequently disappeared. It was in this year that the first modern facility of supplying drinkable water to residents was introduced to the island as part of a project to develop a water source at Gemsan Mountain. It entailed establishing artificial conduits for conveying water to residents from a modern reservoir, which was built on the sites of natural springs that had served as the primary source of drinkable water since historic times. Subsequently, from 1961 onward, underground water, mechanically drawn from deep wells, began to be used as the main source of drinkable water. Until 1964, however, no more than 45 per cent of the residents on Jejudo Island had access to this modern water-supply system.

This system of water supply with the reservoir sourcing water from natural springs, and extraction of ground water through deep wells continued until the 1970s. In 1971, a large reservoir with a capacity to store 100,000 tons of water was constructed at the site of Eoseungsaeng. Following this, two more reservoirs were constructed to supply water to the two main cities of Jejudo Island: Jejusi and Seoguiposi. Further projects of drilling wells were undertaken for exploiting ground water to support daily life and agriculture. As a result, by 1988, 99.5 per cent of the residents on the island could receive drinkable water from a modern water-supply system. By 2015, the number of underground wells had reached a level as high as 4,831 sites. Underground water quantity extraction has reached 85.1 per cent of the amount for sustainable water use, and it may even exceed this level. The natural hazard of drought, an annual impact of climate change, is expected to be a repetitive phenomenon in the long term. Along with the frequent occurrence of drought, an extension of impermeable surfaces would undoubtedly increase the severity of ground water shortage. The drying up of springs is an indication of ground water conditions. Therefore, contaminated spring water is an indication of the pollution of ground water.

4.2. State of current research

At present, spring water represents multiple values: economic, historic, and cultural value, environmental and ecological value, and hydrological and geological value. Until the introduction of the modern public water-supply system, economic value was predominant because springs as a natural resource were critical to human survival. Used for drinking and laundry as well as for agriculture and animal husbandry, the economic value overrode other values. This is reversed today with a lower economic value as spring water is no longer the main source of people's drinking water. Instead, spring water is beginning to be regarded as an important element in attaining the goal of sustainable development on Jejudo Island. Recently, the idea has emerged socially that conservation of spring water would contribute to the protection of the natural environment, including underground water, on the island.

The research has addressed a multiple set of values other than economic value, nevertheless, it is restricted to a single disciplinary perspective. Environmental-ecological value and hydrological-geological value have been emphasised from the standpoint of natural science. A few studies have been undertaken on the assessment and conservation of historical-cultural value, and by extension, heritage value from the viewpoint of history and anthropology. There is further need to conduct an interdisciplinary and thus an integrative study on these values as a whole from the landscape perspective. The Western tradition of dichotomy between culture and nature, indeed, has hindered an integrated approach to the study of spring water as heritage. Therefore, future research should look at the interconnection between historical-cultural value and environmental-ecological value, or hydrological-geological value. The study of spring water on Jeju Island as heritage requires to overcome the imposed division between natural heritage and cultural heritage and participation in the 'Culture-Nature Journey,' as proposed jointly by ICOMOS and IUCN.

5. Threats to water heritage

According to the 'Management plan on spring waters in Jeju Special Self-Governing Province (2016),' 661 sites of springs have survived until today of which, 457 sites still have facilities to protect or tap the spring water, and only 145 sites that have both. The remaining 204 sites lack protection and cater to only tapping facilities. Facilities to protect the sites have been either repaired or reconstructed with modification of the original condition, either totally or partially, to bring down their historic value. Today, the management of spring waters on Jeju Island faces four challenges: obliteration of, or damage to the site; modification or replacement of old form and material at site; depletion, or shortage of spring water; contamination of spring water. These crises are mainly caused by reckless planning and development, especially on the coastal zone. Construction of road and pavement; development of housing; reclamation of tidal flat; exploitation of deep wells through drilling; construction of tourist infrastructure and facilities are some of the destructive activities.

5.1. Obliteration of, or damage to the site

Since 100 per cent of all households on the island received drinkable water from the modern and public supply system in 1986, the management system of spring waters gradually weakened alongside a decrease in individual interest and public attention. The situation worsened as a series of development projects were launched on the coastal zone; these included construction of a paved road, providing housing land, reclaiming the tidal flat, exploiting underground water, developing tourism infrastructure, and so on. These projects clearly transcended the previous ones in terms of scale and speed, causing either obliteration of or damage to many spring water sites. In the process of reclaiming the coastal zone which accompanied these projects, and which aimed to improve our living environment, heritage of spring waters, either tangible or intangible, have been completely lost. Some sites of higher historic values, which had been mentioned in the old documents in the Joseon Dynasty, were victims of this process. Garkkutmul, Seonbanmul, Jonamimul and Oreukomimul are examples of sites buried by reclamation efforts.

5.2. Modification or replacement of old form and material in the site

Between 2006 and 2015, as a result of projects aimed at improving facilities in spring water sites, there were modifications or replacement of their old forms and materials in 80 of the sites. These actions were further responsible for a decrease in the amount of spring water; modification and blocking of the discharge point; degradation of water quality including the appearance of green algae; blocking of sunshine due to the excessive roof facility, modification of and damage to the tub, and disharmony with the surroundings due to the use of modern materials, including steel and concrete, in the reconstruction or re-modelling efforts. This resulted from an ignorance of the historic value of these sites as these projects were usually planned and implemented with a short-term perspective and were approached from the viewpoint of civil engineering, rather than from the standpoint of heritage management.

5.3. Depletion or shortage of spring water

Starting from the 1980s, permissions were easily granted to projects to carelessly drill deep underground wells using machines. Various kinds of construction projects were undertaken which would seriously reduce the ground water capacities. Even though this resulted in the shortage and even depletion of spring water, no attention was paid to the causes of these consequences. In urban areas like Jejusi and Seoguiposi the amount of spring water has decreased substantially. This is probably due to decreasing the permeability of natural land by paving it with asphalt or concrete to expand the urban built-up areas. In rural areas, by contrast, projects to improve drainage to prevent agricultural lands from flooding, in turn reduced the amount of rain water that penetrated the ground. In addition, the construction of golf courses and other facilities in the intermediate mountain zone, and the construction of vinyl houses in the coastal zone contributed to the decrease in permeability.

5.4. Contamination of spring water

According to ground water surveys (2016), only 10 per cent (50 sites) of spring sites meet the quality of potable water. This number indirectly represents the growing concerns around water quality at these sites. According to a water quality survey (2013–2014), the number of spring sites that do not meet acceptable levels of water quality, amount to 73 per cent (387 sites) of the total number of 531 sites. This decrease in water quality may be mainly attributed to an overuse of chemical fertilisers in the intermediate mountain zone and mountain zone, and an incomplete drainage system for wastewater from animal husbandry, for instance.

6. Legal protection in force

It was only at the beginning of the twenty-first century that a social awareness towards spring water sites as a kind of cultural heritage began to emerge and grow gradually. This awareness transformed into a social movement to acknowledge and thus protect the heritage value of spring water under the leadership of Jeju Development Institute, supported administratively by Jeju Special Self-Governing Province. Traditional knowledge and technology were simultaneously utilised in the search for, exploitation and use of spring water at that time. As a result, the entire physical and spatial structure, consisting of discharge points, tubs, shelves, surrounding walls, entrance, and alleys leading to it, often made of natural stones native to the area, is now regarded as a valuable tangible heritage to be adequately protected and managed.

However, legal, and institutional foundation are yet to be established to identify, evaluate and protect tangible and intangible elements which comprise the heritage sites of spring waters. At the moment, there are three kinds of legal instruments in place: one law and two by-laws, namely, the Special Law for the Establishment of Jeju Special Self-Governing Province and Formation of International Free City (1991) (Jeju Special Law); By-Law for the Management of Underground Water in Jeju Special Self-Governing Province (1994) (Underground Water Management By-Law); By-Law for the Conservation of Spring Water in Jeju Special Self-Governing Province (2014) (Springwater Conservation By-Law).

No explicit mention is made of the conservation and management of spring water in the Jeju Special Law. According to the Underground Water Management By-Law, any kind of development project can only be prohibited within 50 m of the source of groundwater. The Springwater Conservation By-Law (2014) was promulgated to enable the administrative authority to implement the policy for the conservation of spring water, but it can only be in effect with the authorisation of the Jeju Special Law. To be effective, it is necessary that the Jeju Special Law should mention explicitly the need to conserve the sites of spring water for their high heritage value, and further commit to the Springwater Conservation By-Law so that it can prescribe the necessary details concerning conservation. In addition, planning for the conservation and management of spring water is not included in the initial stages of spatial planning processes, such as during the preparation of a Comprehensive Plan on the

International Free City and Urban Basic Plan. A mature legal foundation remains to enable administrative authority to conserve the sites of spring water on the basis of the evaluation of their heritage value.

7. Conservation and management of water heritages

7.1. Conservation plan

According to the By-Law for the Conservation of Spring Water in Jeju Special Self-Governing Province (2014) (Springwater Conservation By-Law), a management plan for the spring waters needs to be prepared to enable their scientific conservation. This plan should include a list of spring sites which must be designated for public announcement relating to their conservation policy. Such a policy is based on the idea that spring waters are public resources that have been inherited from the ancestors, and heritage that should be shared and then handed over by the contemporary generation to the next. In principle, the overall management plan should be prepared first and updated every ten years, followed by a complementary one every five years or as necessary. These plans should address development and use, conservation and management, and repair and restoration of spring water.

In 2016, as a follow up, Jeju Special Self-Governing Province prepared a draft of the management plan which would be in effect from 2017 to 2026, with 2015 as the standard year. To implement conservation policies and practices depending on their conservation value, sites of spring waters were classified based on a comprehensive survey from 2013 to 2014. The standards, by which conservation value was assessed, are historical and cultural value; accessibility; amount of spring water; water quality; degree of use by local residents; state of conservation and management. Among these standards, historical and cultural value is closely associated with the cultural heritage value. Among these standards, however, the most important are hydrological-geological characteristics and water quality, which provide information on the possibility of putting these sites into use in the future. The next important standard is the current state of use and management, based on which types of use are classified as drinking, washing clothes and human bodies, and agriculture.

7.2. Management of properties and sites

The sites of spring waters were managed either by the people who used them, or by the village which owned them as public assets. The management method including repair was usually decided by male villagers, but the actual management activity repairs and daily cleaning, were undertaken by women. Men rarely participated in the regular management except when it required intense labour to repair damage to facilities including stone walls after a storm or typhoon. Men were strictly prohibited from the sites of spring waters that were to be used primarily by women. At times, a secondary tub was arranged for men to wash their bodies, separated physically from the primary tub to be used by women. Each village was expected to maintain, protect, and manage the spring waters falling within its territory, and each household in the village was responsible for the payment and labour toward this.

A tube, or multong, was a space constructed within the water channel from a discharge point, representing a woman's life on Jejudo Island as in the past. When using *multong*, women performed a variety of activities, such as drawing water, washing vegetables, doing laundry, and washing their bodies. Indeed, in relation to *multong*, women had to be patient in their labours. They had also to lead their lives in tune with natural time, including the low and high tide. At low tide for instance, the range of time for women to draw water was limited to early in the morning and late at night. At high tide, spring waters were invaded by sea water so that women had to travel farther away to other sites so they could draw water. With high tide, water came in from the sea, and then, in time of ebb, it washed away the waste from the tubs and floors of sites back into the sea. That meant that women did not have too much work to do to to clean the tubs and floors but had the option to voluntarily clear up as needed.

As most spring water sites have lost their original function as the main source of drinkable water since the 1980s, it is becoming more challenging to maintain the traditional management system. For this reason, it may not be possible to maintain the sustainability of traditional management systems in a private capacity unless a secondary management system is constructed at the public level. According to a survey on the contemporary condition of the spring waters (2016), public projects for repair and maintenance of spring waters have been launched by administrative cities and towns since 2006, with a total of 80 projects having been completed by 2015. The lack of public attention and participation of residents continue to pose a challenge to the management of spring waters post completion of these maintenance projects. It is reported that very few spring waters, currently in disuse, met adequate levels of maintenance because of the absence of regular management, and those on the coastal zone were usually cleaned up by villagers, only once or twice every year.

Faced with this management crisis, Jeju (Special Self-Governing) Province is preparing policies and planning their implementation with a final goal to build a sustainable management system. The list of policies are as follows: a complete legal foundation; improvement of the administrative system; the reinforcement of professionalism; the construction and operation of an information system; setting up a governance system. A sustainable management system presents the objectives to enhance the effectiveness of management and planning, which should be pursued in four directions: maintenance of sustainability in the quantity and quality of water; maintenance of the balance between conservation and use; construction of a legal and institutional foundation and improvement of professionalism in the management organisation; community participation. Above all, participation of the community and other stakeholders, in particular, is primarily essential for the establishment of governance which will enable the development of an effective management system in the public sphere.

7.3 Sustainable conservation and use of living properties: The village called Jocheonri

Jeju Province has maintained that a sustainable way of conserving and managing spring water sites requires active community participation in the management system. Spring waters are usually located within the boundaries of a 'water body that is commonly, or publicly owned', a 'stream that is owned publicly by the state', and 'land that is privately owned'. It is also a tradition that these sites have been managed voluntarily by villagers, privately following their customary law rather than the written public law. This reiterates that governance must be based on voluntary and active participation of the community and other stakeholders. This system of governance should be built upon the interaction between a wide range of stakeholders: administrative bodies and other public organisations, professionals, residents, business enterprises, and NGOs involved in issues concerning environmental protection. Setting up such a system makes it possible to attain the final goal of sustainable management of spring waters.

Jeju Province has launched an experiment to financially support a voluntary project in a village called Jocheonri that aims to builds a governance system to manage spring waters within its village territory while providing professional advice. The project aims to utilise spring waters as a resource for tourism after revitalising the facilities at these sites. The members of the village acknowledge that spring waters could offer a testimony to the history of their village and their pride and identity. Villagers have explored the tangible and intangible heritage embedded in these sites and interpreted them to compose a storyline for visitors to see, listen to, and enjoy. What is peculiar to this storytelling is the inclusion of the ecological and environmental elements from the viewpoint of natural heritage, in addition to the historical and cultural elements from the standpoint of cultural heritage. This elementary effort offers an integrated approach to the heritage management of spring waters, bridging the dualism between cultural and natural heritage.

The village called Jocheonri is located on the coast, 50 m above sea level, and 12 km east of Jejusi City (Fig. 2). One of the two most important public ports on Jeju Island, called Jocheonguan, had already been constructed, and used even before 1439, on the land facing the coastal inlet to the village. It continued to serve as a busy port for departure and arrival to the island. At the port, a defensive fort surrounded by stone walls, called Jocheojinseong, was reconstructed in 1590, to defend against the Japanese pirates. The detailed descriptions of an agglomerated settlement called Jocheonri can be identified on old pictorial maps which were drawn in the late seventeenth century, and the early and late eighteenth century. This indicates that the village of Jocheonri was spread out as a large settlement even by that time. It is believed that the growth of the settlement to that size may have been the result of the availability of drinkable water from natural springs around the coastal inlet called Jocheonpogu.

Traditionally the village was famous for the richness in quantity and quality of its spring waters. It is said that a total of 41sites had once been used, but now only 30 sites are identifiable. These sites have survived the process of modern development, accompanied with the destruction of, or damage to the spring waters. There is an abundant supply of spring water, with protection facilities ensuring that they are maintained in a relatively stable condition. Furthermore, 20 sites are still being used as a source of drinking water, and for laundry and bathing, and even washing sea-products. Since these sites can be used as a type of living heritage, the villagers from Jocheonri agreed on the plan to develop 'cultural trails to explore spring waters' for tourism. Based on the plan, the project to develop trails was launched in 2018, and completed in 2019. In the process, two sites have been rehabilitated through reconstruction. Extensive roofs covering large parts of several sites has been removed. The project includes officially selecting and professionally training villagers to contribute as guides to the sites for interpretation and presentation.

Conclusion

Today, management of spring water sites on Jejudo Island face four kinds of crises: obliteration of, or damage to the site; modification or replacement of old form and material at site; depletion or shortage of spring water; contamination of spring water. These crises have resulted from reckless planning and development, especially on the coastal zone, such as, construction of roads accompanied by pavements; development of housing land; reclamation of tidal flats; exploitation of deep wells through drilling; construction of tourist infrastructure and facilities.

It was only at the beginning of the twenty-first century that social awareness of spring water as cultural heritage began to emerge and grow gradually. Such an awareness could grow into a social or environmental movement to perceive and thus protect the heritage value of spring water under the leadership of Jeju Development, supported administratively by Jeju Special Self-Governing Province. It is appreciated that traditional knowledge and technology were utilised to the maximum for the search, exploitation and use of spring water at that time. The wholeness of physical and spatial structure, consisting of springs, tubs, shelves, surrounding walls, entrance, and alleys leading to it, often made of natural stones native to the area, are now regarded as tangible heritage to be protected and managed.

As most of the spring water sites have lost their original function as the main source of drinkable water since the 1980s, it is becoming more and more difficult to maintain their traditional management system. This makes it challenging to maintain the sustainability of such a traditional management system at a private level, without the support of a secondary management system constructed at the public level. Faced with such a management crisis, Jeju (Special Self-Governing) Province is planning on policies and their implementation with a final goal to construct a sustainable management system. The list of policies includes: a legal foundation for the conservation and management of spring water; improvement of the administrative system in relation to the management of spring water; reinforcement of professionalism on the conservation and management of these sites; construction and operation of an information system in relation to spring waters; setting up of a governance system for the management of spring waters.

Jeju Province has indicated that a sustainable way of conserving and managing spring waters requires active participation of the community in the management system. Spring waters are usually located within the boundaries of a 'water body that is commonly, or publicly owned', 'stream that is owned publicly by the state', and 'land that is privately owned'. The site has been traditionally managed voluntarily by villagers, privately following their customary law over written public law. Therefore, it becomes necessary that their governance should be constructed with the voluntary active participation of the community and other stakeholders in relation to spring waters. Such a governance system should be the result of the interaction between a wide range of stakeholders: administrative bodies and other public organisations, professionals, residents, business enterprises, and NGOs involved in issues concerning environmental protection.

The history and culture of Jejudo Island, however, cannot be considered separately from the history and culture of spring water. It is therefore, appropriate to further explore the data sources, written or oral, to study the historical and cultural aspect of spring water in more detail: The relationship between spring water and the origin of settlement, between spring water and agriculture (and husbandry), between spring water and belief (and ritual), between spring water and medical treatment, between spring water and village ethical code, between spring water and tradition (and custom) on the exploitation and maintenance, and between spring water and tradition (and custom) on protection. The most urgent task is the survey to collect and compile the historical data concerning the springs which were used as the sources for drinking water.

Though the research focused on a multiple set of values other than economic value, including heritage value, the study was restricted to a single disciplinary perspective. Further emphasis has been placed on the research of both environmental-ecological value and hydrological-geological value from the standpoint of natural science. A few studies have been targeted at the assessment and conservation of historical and cultural, and by extension, heritage value from the viewpoint of history and anthropology. Very few attempts, however, have been made to conduct an interdisciplinary and integrated study of these values from a landscape perspective. Therefore, research attention, in the future, should be paid to the interconnection between historical-cultural value and environmental-ecological value, or hydrological-geological value, and finally an interaction of these values, that is, heritage value.

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Case study: The sustainable conservation and use of living properties: the case of the village called Jocheonri

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1. An experimental project at the village level

It is the standpoint of Jeju Province that sustainable conservation and management of spring waters should require the active participation of the community in the management system. Spring waters are usually located within the boundaries of a 'water body that is commonly, or publicly owned,' 'stream that is owned publicly by the state,' and 'land that is privately owned.' It is also a tradition that they have been managed voluntarily by villagers, following their customary law rather than written public law. That is why the governance must be constructed with the voluntary active participation of the community and other stakeholders. It is only after the construction of such governance that it will be possible to attain the final goal toward sustainable management of spring waters. Such governance, however, should be built up through interaction between a wide range of stakeholders: administrative bodies and other public organisations, professionals, local residents, business enterprises, and NGOs involved in the issues concerning environmental protection.

With such an idea in mind, Jeju Province has launched an experimental project to financially support a voluntary project by a village called Jocheonri to build up a governance to manage spring waters within its village territory while providing professional advice. The project involves using spring waters as a resource for tourism after revitalising the facilities in their sites. The members of the village also have come to realise that spring waters could testify to their village history and represent their pride and identity. Villagers have explored the tangible and intangible elements of heritage that have been embedded in the spring water sites, and interpreted them to compose a storyline to tell the stories to visitors from outside to see and listen, and finally enjoy. What is peculiar to this storytelling is the inclusion of the ecological and environmental elements from the viewpoint of natural heritage, in addition to the historical and cultural elements from the standpoint of cultural heritage. This elementary effort can be thought of as an integrated approach to the heritage management of spring waters, beyond dualism between cultural and natural heritage.

2. The current state of spring water sites

The village called Jocheonri is located on the coast, 50 m above sea level, and 12 km east of Jejusi City. On the land, facing the coastal inlet in the village, one of the two most important public ports on Jejudo Island, called Jocheonguan, had already been constructed and used even before 1439. After then, it continued to serve as a busy port from which to depart from and arrive at the island. A defensive fort, surrounded by stone walls, called Jocheojinseong, was reconstructed in 1590 in the port, in order to defend against Japanese pirates. The detailed descriptions of an agglomerated settlement called Jocheonri can be identified on the old pictural maps which were drawn in the late seventeenth century, and in the early and late eighteenth century. This means that Jocheonri Village was a large settlement in terms of size even by that time. It is said that the growth of a settlement up to that size might have

Fig. 1: Ken-mul on the front and Jocheonjinseong Walls and Hallasan Mountain in the background.

been possible with the availability of drinkable water from natural springs around the coastal inlet called Jocheonpogu. (Fig. 1).

The village has been traditionally famous for the quantity and quality of its spring waters. It is said that a total of 41 sites had once been used before the 1980s, but now only 30 sites are identifiable. These sites have survived the process of modern development, accompanied by the destruction of and damage to the spring waters. Until the 1980s most of these spring waters were used for drinking and other purposes such as washing vegetables, and human clothes and bodies. People used their traditional experience and knowledge to distinguish the quality of water among them and decided which one would be suitable for drinking water. Within the territory of a hamlet, people assigned spring waters with different uses according to the quality of water, such as drinking, washing vegetables and clothes, human bodies and even drinking water for cows and horses. (Fig. 2).

Today, even without the use of drinking water, there is still abundant spring water, with protection facilities being maintained under relatively stable conditions. Of these, 22 sites are still being used daily for laundry and bathing, and even washing sea-products, other than drinking. (Fig. 3). The most dominant trend in use is toward bathing water for residents and sometimes for tourists while maintaining separation in the space between men and women. (Fig. 2). Their locations can be grouped into four groups, roughly corresponding with the territories of hamlets, which have grown naturally around the port: Sangdong, Jungsangdong, Jungdong, Hadong. (Fig. 4).

Number on the Map (Fig. 4)	**Spring Water**	**Naturally Grown Hamlet**	**Function and Use**	
			Before the 1980s	***After the 1980s***
1	Gue-mul	Sangdong	Drinking water and habitat for birds	Habitat for birds
2	Jeolgan-mul		Drinking Water	
3	Suruk-mul Yeotang		Sacred water for prayer	

4	Suruk-mul Namtang		Men's Bath	Men's bath
5	Apbille-mul		Slaughtering pigs and washing their products	
6	Suamjeong-almul		Washing vegetables and clothes	
7	Eong-mul Namtang		For men's bath	Men's bath
8	Eong-mul Yeotang		Women's bath	Women's bath
9	Eong-mul Ppanlaeteo		Drinking, washing vegetables and clothes	
10	Jejujari-mul		Sacred water for rituals	
11	Sae-mul		Drinking water and washing clothes	
12	Sangdongdumalchi-mul		drinking water and children's bath	
13	Gaenanggye-Namtang	Jungsangdong	Men's bath	Men's bath
14	Gaenanggye Eong-mul		Drinking water, washing vegetables and clothes	
15	Dorit-mul		Drinking water	
16	Jokbak-mul	Jungdong	Drinking water	

17	Bille-mul		Drinking water and monks' bath	
18	Dumalchi-mul		Drinking water	
19	Jangsu-mul		Drinking water and washing clothes	
20	Saengyi-mul	Hadong	Drinking water	
21	Jageundonji-mul		Men's bath	Men's bath
22	Keun-mul		Drinking water, washing vegetables and clothes, and bathing	

Fig. 2 The function and use of spring water before and after the 1980s.

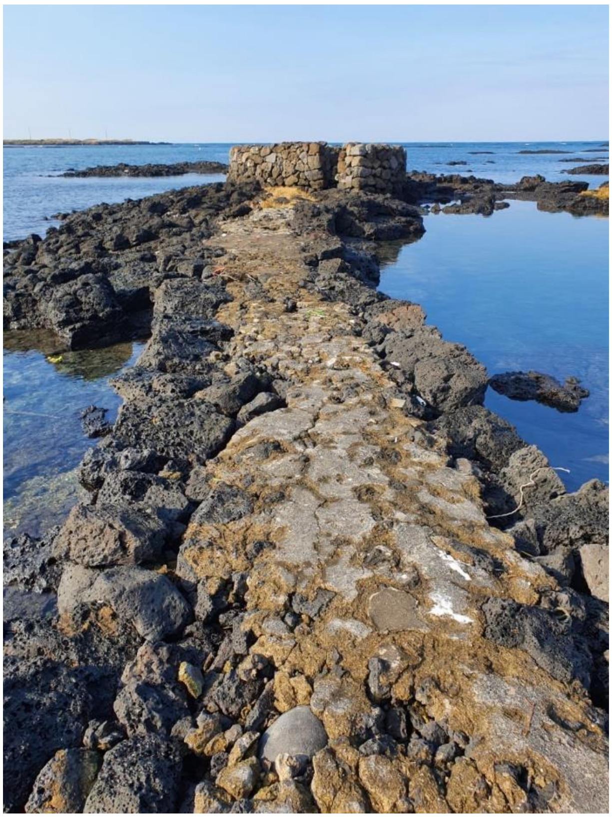
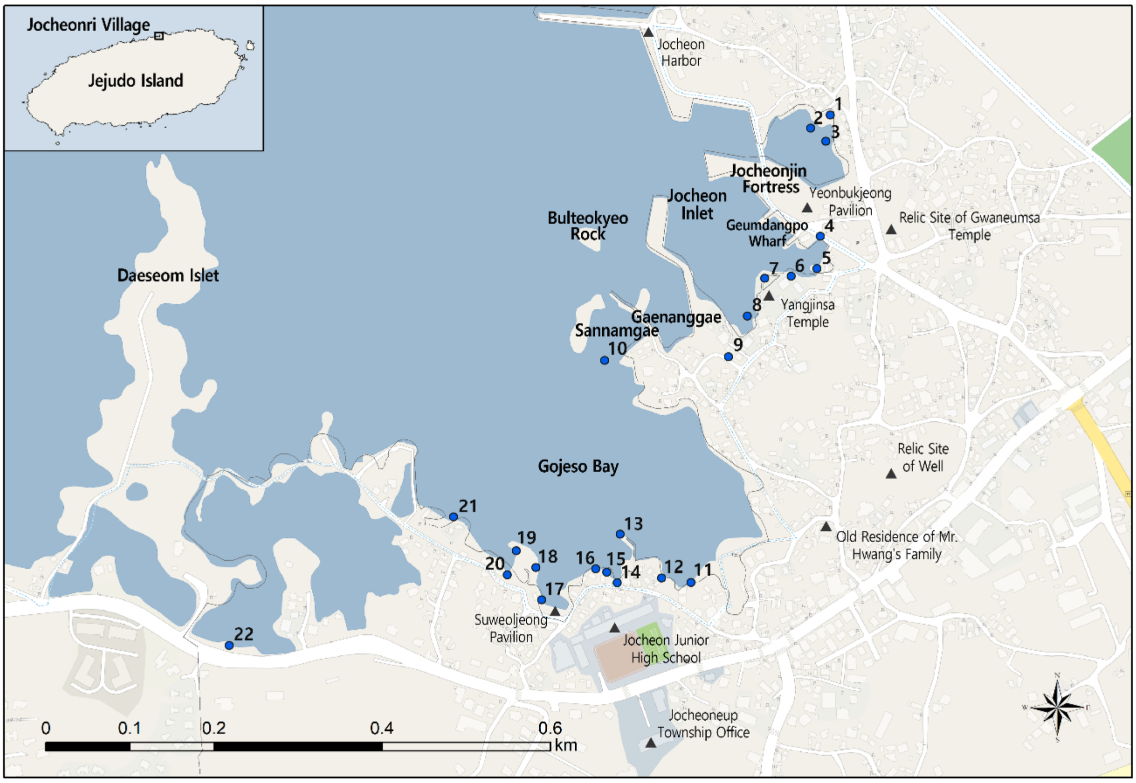


Fig. 3: Jejujari-mul and the alley leading to its entrance.



1. Keun-mul 2. Jakdonji-mul 3. Saengyi-mul 4. Jangsu-mul 5. Dumalchi-mul 6. Bille-mul 7. Jokbak-mul 8. Dorit-mul 9. Gaenanggae-eongmul
10. Gaenanggae-namtang 11. Sangdongdumalchi-mul 12. Sae-mul 13. Jejujari-mul 14. Eongmul-ppaleteo 15. Eongmul-yeotang
16. Eongmul-namtang 17. Suamjeong-almul 18. Apbille-mul 19. Surukmul-namtang 20. Surukmul-yeotang 21. Jeolgan-mul 22 Gue-mul

Fig. 4: Locations of spring waters in Jocheonri Village (2019).

3. The past and contemporary management system

In Jocheonri Village, the maintenance and management including repair were generally taken care of by the residents around the spring. Women, in particular, were traditionally in charge of preventing the spring water from being contaminated by wastes and cleaning it up when it was contaminated after the tidal invasion and retreat. Because women were responsible for tapping and carrying home the drinkable water from the spring, they could naturally carry out the daily care of spring water, including regular maintenance of water quality. Only when stone walls surrounding the site of spring water were destroyed by storms and other natural hazards, did the head of the village call for a meeting of the male residents who were responsible for their restoration However, since the 1960s and especially the 1980s, such a traditional management system has gradually stopped to function because the spring water was no longer a source of drinking water.

In 2016, then, with financial support from the Office of Jeju Special Province, the head of the village began to launch a series of projects to restore and preserve the sites of spring waters that had been largely abandoned. Based on these projects, the village were able to prepare 22 spring water sites for presentation of their heritage value to the public. As these sites could be used as a type of living heritage, the villagers from Jocheonri agreed on the plan to develop ‘the cultural trails to explore spring waters’ to attract tourists from outside. Based on the plan, the project to develop trails was launched in 2018, and completed in 2019. (Fig. 5). In the process, two sites have been rehabilitated through reconstruction, and roofs excessively covering several sites have been taken off. Of course, it will be the villagers themselves who will guide the visitors to the sites with interpretation and presentation; they will be officially selected and trained to professional standards.

In 2019, an association to conserve the spring waters was organised at the village level; the association consisted of the head and members of the village, as well as NGOs, and the president of Jeju Eco-Tourism Association. In cooperation with other organisations in the village, this association is planning to lead activities and develop programmes to provide the public with information and experience on the value of the spring waters, and to monitor the conservation and management. There are 13 volunteers from the village and the president and general secretary are selected from among them. The activities for the conservation and management of the spring waters are expected to be planned and implemented while depending mainly on its own budget. The list of activities includes: daily conservation and management of the spring water sites and surroundings; a programme to provide students with experience and education; professional lectures on animal and plant ecology in association with the history of the village and spring waters; and finally training of selected villagers as enthusiastic interpreters who can present the heritage value of spring waters to the public.

Fig. 5: Trails to explore the sites of spring water in Jocheonri Village (2020).

Selective bibliography

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Byeong-ryun Ko, 2016. Spring Waters on the Island, Design Blue Ant. (in Korean).

* * *

3. Japan

Regional overview: Water Heritage in West Japan

By Takashi Itoh, Chief Researcher of the Industrial Heritage Information Centre, Japan

Water heritage varies depending on climate, geological structure, geographical features, historical conditions peculiar to the community of the region. In this paper, we summarise the climate and geographical features of West Japan and give an overview of the water heritage of West Japan.

1. West Japan climate

Climate affects production activities such as agriculture and fishery, way of living, and therefore the relevant water heritage.

Japan's climate may generally be classified as follows: Most regions belong to the temperate zone, besides Hokkaido (subarctic) and the Nansei Islands (subtropical). The West Japan area has a temperate zone and a subtropical zone. The temperature zone is further subdivided into four divisions: the Sea of Japan side, the Pacific side, the Inland Highland, and Setouchi. Fig.1 shows the climatic division in Japan.

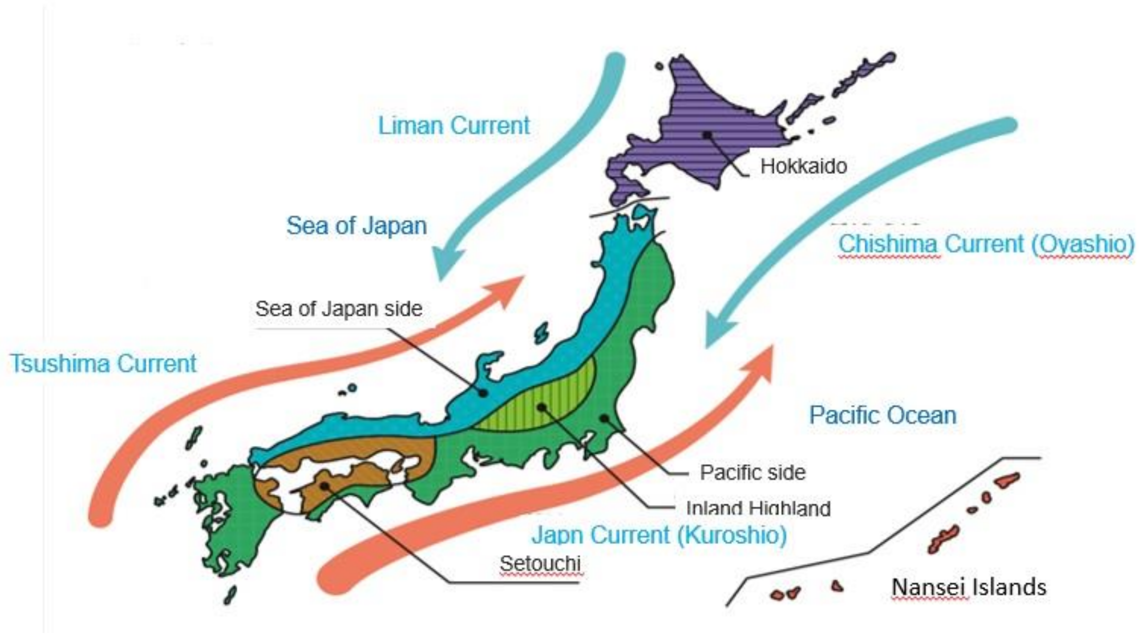

Fig. 1: Climate Classification of Japan.
https://happylilac.net/pdf/pg0016-005-02.pdf *(Browsing 2020.3.30). Translated from Japanese to English.*

1.1. Climate on the Pacific side

West Japan is strongly affected by the warm Japan current (Kuroshio), so that summer is hot and humid due to the warm and damp monsoon from the Pacific Ocean, while winter is dry due to cool and dry winds from the continent. Heavy rains extend from summer to autumn, and frost and snow rarely occur even in the cold winter. This area thrives with vegetable and flower farming. Tea farming is common in the Kagoshima Prefecture.

1.2. Climate on the Sea of Japan side

The Tsushima current, which is a warm current, flows on the Sea of Japan side and carries warm, moist air. However, in winter, the cold, dry winds from the Eurasian continent cool the damp winds of the Tsushima current to snow. This results in unusually heavy snow for the temperature making this one of the world's high snowfall areas. Farming is not possible in winter due to this but the thaw during spring results in rice paddy cultivation from spring to autumn.

Further, hydroelectric power generation utilising abundant snowmelt has been actively carried out popularising this area as Japan's power zone.

1.3. Inland highland climate

The large temperature gap between hot summer and below freezing point in winter, warm, dry air in summer can cause a *Foehn* phenomenon, which can further increase summer temperatures. However, the summer temperature does not rise in high altitudes areas.

There is little rainfall throughout the year because rain falls on the Pacific Ocean side in summer and snow falls on the Sea of Japan side in winter. Rice farming is not immensely popular in this area although there are many water sources, because there are few flatlands. Instead, cultivation of fruits is suited to these sunny mountains and dry climate.

1.4. Setouchi Climate

The temperature is partly warm because it faces the Seto Inland Sea. Since the summer monsoon is interrupted by the Shikoku Mountains and the winter monsoon is interrupted by the Chugoku range precipitation is therefore low. A short rainy season or absence of typhoons result in droughts.

People created reservoirs on land adjacent to farmland to address water shortage. In addition, it became necessary to construct a dam (Northern Tokushima, the Yoshino River in Kagawa Prefecture) to collect rainfall from the mountains on the Pacific Ocean side while rain falling on the Sea of Japan side flows through the river, natural lakes, and marshes upstream (Lake Biwa in the Kinki Region, etc.).

Reservoirs are on a downward trend due to the development of residential land and improved water use, but there are still large and small reservoirs in the Senshu area of Osaka Prefecture, the Higashi-Harima area, and Awaji Island (some of which have lost their original use) of Hyogo Prefecture. There are numerous reservoirs in Kagawa Prefecture due to the presence of few mountains and the fact that water is scarce.

1.5. Climate of Nansei Islands

Nansei Islands from Amami Oshima in Kagoshima Prefecture to Okinawa Prefecture, have a subtropical climate between tropical and temperate zones. The average temperature in winter is about 15°C, which is warmer than that of Honshu (the main island of Japan) but is not extremely hot in summer (excluding Yaeyama Islands), because it faces the Pacific Ocean. The annual rainfall is high due to warm and damp winds from the Japan current. There is a minor temperature gap between day and night, and summer and winter. The monthly rainfall in the rainy season and the dry season in Naha City, Okinawa Prefecture, which is a representative city of the Nansei Islands region, is as follows:

Rainy season (May–Sep., except July): 230–260 mm

Dry season (Nov–Feb.): 100–150 mm. The area experiences high rainfall throughout the year.

The lack of large rivers often results in a shortage of water in this area. Due to frequent typhoons the agriculture practiced is mainly upland farming. Pineapple and sugarcane farming are more popular than rice cultivation. In recent years, in additional to tropical fruits such as mango and papaya, flower and vegetable farming have become popular due to the warm temperatures.

2. Tectonics and granitic distribution of West Japan

Geological features are important for structural purposes used for foundations and as construction material. The use varies depending on the region and age. Structures may be characterised by their region and the time of construction.

Geographical structure in West Japan is distinct from that in East Japan.

Fig. 2 shows the locations of the Central Tectonic Line, the Itoigawa Shizuoka Tectonic Line and the distribution map of granites. The Central Tectonic Line is the world's first-class fault that runs from Western Kyushu to Kanto in West Japan. The figure shows the Itoigawa Shizuoka Tectonic Line (the north-south vertical line in the figure). The Itoigawa Shizuoka Tectonic Line is a fault that runs from Itoigawa, Niigata Prefecture to Oigawa, Shizuoka Prefecture.

Granites show three types of distribution. Triassic・Jurassic (240 to 180 million years) coloured purple, Cretaceous・Cenozoic Paleogene (130 to 40 million years) coloured red and Neogene (30 to 4 million years) coloured orange. Among them, Cretaceous and Cenozoic Paleogene coloured red are widely distributed. In relation to water heritage, it is worth noting that granites are concentrated around the Seto Inland Sea and Aichi Prefecture.

In the Kyushu Area, there are many arched Stone Bridges and structures made of welded tuff. It was formed by many volcanic activities including Mt. Aso. In the large eruption at Mt. Aso which produced a very large 'caldera', a well-known volcanic phenomenon in the world, the pyroclastic flow created a wide plateau around the hill, and along the valley and reached the east, north and west coasts of Kyushu Island, besides crossing the sea and spreading to Amakusa Shimabara in Nagasaki Prefecture and Akiyoshidai in Yamaguchi Prefecture.

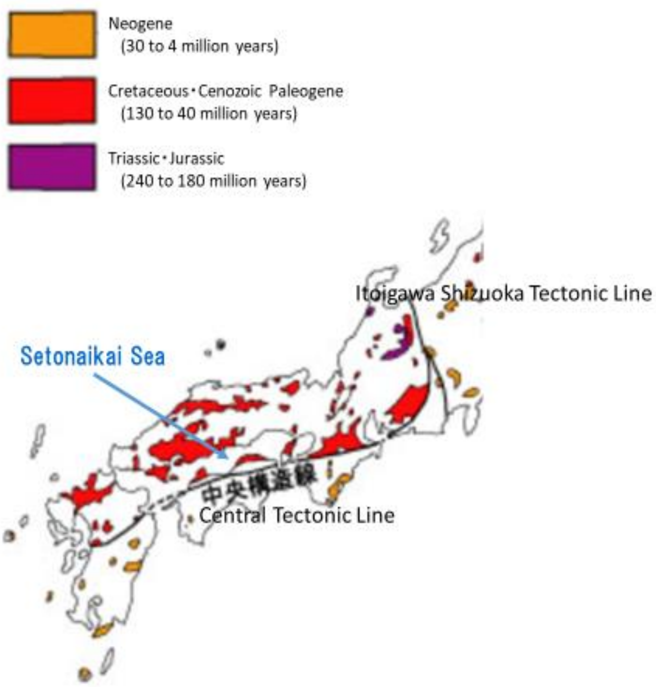

Fig. 2: Geological Tectonic Line and Granitic Distribution Map of West Japan.
[chigaku.ed.gifu-u.ac.jp/chigakuhp/html/kyo/chisitsu/kakougan/granite-distribution.html] (Browsing 2020.3.30).

3. Overview of water heritage in West Japan

As shown in the 15 Tables below, the overview of Water Heritage in West Japan can be observed from four perspectives: Structure, Group, Network, and System, with a point of 'cultural value of landscape' added respectively.

'Structure' can be divided functionally into 'Water Use', 'Flood Control', 'Familiarity', and 'Religion' depending on the role played by the structure. Above all, 'Water Use' can be sub-divided further into various uses, drinking water, irrigation, agricultural and forestry facilities, transportation, power source, defence, health and recreation, etc. In addition, various structures have been created by age. Even with structures with the same function, trends such as changes in name, enlargement in size, and structural diversification can be identified from one period to another.

'Group' means a group of structures of the same kind such as bridges and water gates, or various water-related structures, that are attractively organised in the landscape.

'Network' is a link or relation connected by a single function, such as an irrigation canal or a waterway. One network may include multiple structures, such as water gates, weirs, gutters, locks, and pumping facilities.

'System' can be said, on the other hand, to be one unit, composed of elements differing in function - structures and facilities – which are connected directly or indirectly with each other. The water from upstream to downstream shows various functions along the way, such as 'water use', 'flood control' and 'familiarity', and finally flows out to sea, forming a large system. To a large extent, we can also focus on the unity of the entire basin. When you expand the area to a city or a region, a basin, a sphere, national boundaries, and the earth, the relevance of each element or unit is evident. As we approach modern times, we can see that the relationship has become clearer and closer. This paper omits consideration of national and global levels.

In the attached tables, the Water Heritage in West Japan is classified in rows indicating three age divisions of history, Ancient, Early Modern, and Modern, for convenience, although originally the Medieval Era should have been inserted between Ancient and Early Modern. The columns display the order of Perspectives, i.e., 'Structure', 'Group', 'Network' and 'System' as mentioned above. As an exception, currently functioning cases have been described under the historical context of Present Time.

Actual cases corresponding to each item in the table are described below, giving priority to Perspectives and Functions. Some of the interesting cases have been explained in detail.

3.1. Structure

3.1.1. Water use

1) Drinking water

	Function		Ancient Times	Early Modern Times	Modern Times
Structure	Water Use	Drinking Water	Pond, Well	Well, Lateral Well, Intake Weir,Aqueduct,Siphon, Tunnel, Water Supply	Well, Intake Weir, Aqueduct, Siphon, Tunnel, Water Supply Facility

Fig. 3: Drinking water through time. © *Takashi Itoh.*

Early modern times

・ Tatsumi irrigation waterway in Kanazawa City in Ishikawa Prefecture

(This provides water for agriculture as well)

Modern times

・ Structures of water supply facilities in various places

2) Irrigation Water

	Function		**Ancient Times**	**Early Modern Times**	**Modern Times**
Structure	Water Use	Irrigation Water	Twig Weir, Reservoir, Waterway	Agricultural Waterway, Daily Life Waterway, Waterway, Rservoir, Water Gate, Tunnel, Pumping Waterwheel, Fire Extinguishing Water, Fire Prevention Water, Siphon	Agricultural Waterway, Industrial Waterway, Waterway, Rservoir, Water Gate, Tunnel, Pumping Station, Drainage Pump Station, Fire Extinguishing Water, Fire Prevention Water, Dam, Cylindrical Diversion Work, Siphon

Fig. 4: Irrigation Water through time. © *Takashi Itoh.*

Early modern times

(Irrigation waterways can basically be found wherever rice fields have expanded)

・ Tatsumi Irrigation Water in Kanazawa City

(This combines agricultural water and familiarity water)

・ Creek in Saga Plain in Saga Prefecture

Modern times

・ Honen-ike Dam and Reservoir in Kagawa Prefecture

3) Agriculture and Forestry Facilities

	Function		**Ancient Times**	**Early Modern Times**	**Modern Times**
Structure	Water Use	Agriculture & Forestry Facilities	Reservoir, Water Gate	Rearing Pond, Timber Pond	Rearing Pond, Timber Pond, Fishway of Weir, Raft Conveyance Way of Dam

Fig. 5: Agriculture and Forestry Facilities through time. © *Takashi Itoh.*

Ancient times

・ Sayama Pond in Osaka Prefecture: Japan's oldest earth dam type reservoir

・ Manno Pond in Kagawa Prefecture: Japan's largest earth dam type irrigation reservoir

Early modern times

・ Tsuujun Bridge that blows water from the top of the arch crown, *Tsuujun* irrigation waterways, and the surrounding landscape of terraced rice field area, *Shiraito* Plateau, in Kumamoto Prefecture cf.3-2(2) *Arch Stone Bridges Group*

Modern times

・ *Hakusui* Dam, reputed to be the most beautiful in Japan, and Fujio Irrigation Waterway in Oita Prefecture

・ *Meisei* Irrigation Waterway and Stone Arch Aqueducts in Oita Prefecture

4) Transport

	Function		**Ancient Times**	**Early Modern Times**	**Modern Times**
Structure	Water Use	Transport	Bridge, Canal, Harbor	Canal & River, Lock, Cutting Waterway, River Port, Light House, Dock, Bridge, Movable Bridge, Water Boat, Ferry Boat	Canal, Lock, River Port, Light House, Dock, Tunnel, Bridge, Movable Bridge, Crane Water Boat, Ferry boat, Incline

Fig. 6: Water used for transportation through time. © *Takashi Itoh.*

Ancient times

・ Asuka Canal in Nara Prefecture

Early modern times

・ Takahashi River Canal and Lock in Okayama Prefecture

・ Onga-horikawa River and Karato Water Gate in Fukuoka Prefecture

(For a complex purpose of shipping to Wakamatsu and for irrigation)

5) Power

	Function		**Ancient Times**	**Early Modern Times**	**Modern Times**
Structure	Water Use	Power		Powder Mill	Dam, Power Plant

Fig. 7: Water and power through time. © *Takashi Itoh.*

Early modern times

・ Water Mills in various places

Modern times

・ Hydroelectric Power Plants in various places

6) Defence

	Function		Ancient Times	Early Modern Times	Modern Times
Structure	Water Use	Defence	Moat, Castle	Moat, Castle	

Fig. 8: Water and defense trough time. © *Takashi Itoh.*

Medieval times

・ Sakai Moat Village in Osaka Prefecture

・ Imai Moat Village in Nara Prefecture

Early modern times

・ Castle Moats in various places

7) Health and Recreation

	Function		Ancient Times	Early Modern Times	Modern Times
Structure	Water Use	Health & Recreation	Hot Spring, Pleasure Boat, Fishing Place & Hut, Stepping Stones	Hot Spring, Pleasure Boat, Fishing Place & Hut, Stepping Stone Bridge, Fall, Sprinkled Water, *Suikin-Kutsu*, *Shishi-Odoshi* (Deer-Scarer), Fireworks	Hot Spring, Pleasure Boat, Fishing Place & Hut, Stepping Stone Bridge, Fishing Pond, Cascade, Fall, Sprinkled Water, *Suikin-Kutsu*, *Shishi-Odoshi* (Deer-Scarer), Fireworks

Fig. 9: Water used for Health and Recreation through time. © *Takashi Itoh.*

Early modern times

・ Hot Springs in various places

・ Wells and garden ponds at *Daimyo* residences, shrines, and temples in various places

Modern Times

・ Hot Springs in various places

・ Wells and garden ponds for nobility residence, government official houses, and private company official houses in various places

3.1.2. Flood control

	Function	Ancient Times	Early Modern Times	Modern Times
Structure	Flood Control	Embankment, Water Gate	Embankment, Ring Embankment, Discontinuous Embankment, Water Gate, Steps Waterway, Sabo, Training Embankment, Groin (Spur Dike),	Embankment, Water Gate, Steps Waterway, Sabo, Training Embankment, Groin (Spur Dike), Retarding Basin,

Fig. 10: Flood control through time. © *Takashi Itoh.*

Early modern times

・ Stone Sabo Dam at the *Dodogawa* River in Hiroshima Prefecture

Modern times

・ Sabo dams designed by De Rijke in various places

・ Shiraiwa Sabo Dam in Toyama Prefecture

3.1.3. Familiarity

	Function		Ancient Times	Early Modern Times	Modern Times
Structure	Familiarity			Garden Water, Fall, Pond	Well, Intake Weir, Aqueduct, Siphon, Tunnel, Water Supply Facility

Fig. 11: Water and Familiarity through time. © *Takashi Itoh.*

Present time

・ Tatsumi Irrigation Waterway flowing through Samurai Residential Area in

Kanazawa City

・ Familiarity Water of Irrigation Water in various places

3.1.4. Religion

	Function		Ancient Times	Early Modern Times	Modern Times
Structure	Religion		Utaki1), Waterway, Pond, Chikubujima Island in Shiga	Tiny Shrine for Water God	Tiny Shrine for Water God

Fig. 12: Water and religion through time. © *Takashi Itoh.*

Ancient times

・ Waterway including the *Kamegata* (Turtle Shaped) Stone Tank and *Asuka-kyo* Monument Pond (seventh century), etc. in Nara Prefecture

・ Utaki[1)]: A space in a forest, a spring, a river, etc. usually, otherwise a whole island exceptionally. In ancient society, water sources were sacred due to the nature of the land around Okinawa Prefecture, which is made up of Ryukyu limestone with poor water retention. Utaki is a general term for the sanctuary established by the Ryukyu Kingdom (the Second *Shoshi* Dynasty) and is originally thought to be a place where settlements existed in ancient times (there is a different view as well).

3.2. Group

3.2.1. Group of reservoirs

Early modern to modern times

・ Reservoirs in Kagawa Prefecture, in Senshu Area in Osaka Prefecture, and in Eastern Harima Area and Awajishima Island in Hyogo Prefecture

3.2.2. Group of arch stone bridges

	Function		Ancient Times	Early Modern Times	Modern Times
Group			Ancient Tombs	Bridges, Arch Stone Bridges2), Water Gates,	Bridges, Arch Stone Bridges, Sinking (or Submerging) Bridges3),Water Gates, Dams & Power Plants4) 5)

Fig. 13: Water and bridges through time. © *Takashi Itoh.*

Arch stone bridges of early modern and modern times are concentrated in the Kyushu area. It is close to Nagasaki and Okinawa, where the stone technique was first introduced, and is rich in welded tuff as the material stone which was easy to work with. The stone masonry does not use cement as an adhesive and is characterised by rockwork using the frictional force of stone.

Early modern to modern times

・ Arch stone bridges in the *Midori* River system in Kumamoto Prefecture:[2)] There are more than 80 arch stone bridges, some of which represent this structure in Japan, such as Tsuujun Bridge which is known as a bridge that blows water from the top of the arch crown, Reidai Bridge with the longest span in Japan, Futamata Megane Bridge with a twin arch at the junction of two rivers.

Fig. 14: A group of stone bridges of Midorikawa (Kumamoto Pref.) – The scenery of continuous stone arch bridges in rural area. © *Kazuyuki Yano.*

Modern times

・ 60 arch stone bridges in the *Era* River Valley in Oita Prefecture

3.2.3. Bridges group

Modern times

・ Nakanoshima Island bridges in the *Yodogawa* River in Osaka Prefecture

Present time

・ Sinking (or Submerging) Bridges of the *Shimanto* River in Kohchi Prefecture: The concrete bridges that submerge in the river during floods are built close to the water surface. It is perhaps because their construction was technically easier and less expensive than bridges with higher piers. It is a living bridge mainly for pedestrians rather than transport logistics.

Fig. 15: Shimanto River (Kōchi Pref) – Cultural lifestyle by Clear River. © *Kazuyuki Yano.*

3.2.4. Dams, power plants and bridges

Modern times

・ Dams, power plants and bridges in the Kiso river system in Nagano, Gifu, Aichi and Mie Prefecture:[4)] To avoid the destruction of scenic beauty caused by the construction of power plants, Momosuke Fukuzawa (1868-1938, Japanese businessman) invited architect Shiro Sato (1883–1974) to request a design of the power plants in consideration of the surrounding landscapes.

・ Dams and power plants in the Tenryu River system in Nagano, Aichi and Shizuoka Prefectures:[5)] The Tenryu River is located in the geologically disordered area of Fossa Magna, so sediment tends to accumulate in the dam lake. For example, at Yasuoka Dam (built in 1935), sediment is deposited in the dam lake, and the surface of the dam can be seen as being eroded by the sediment stream.

3.2.5. Water gates, cf.3-4 (3) irrigation waterways and water gates

Early modern to modern times

・ Water gates made of stone, brick and tataki (finished by mixing lime and water with fine granules of granite, kneading, and squeezing) in Yatsushiro reclaimed land in Kumamoto Prefecture

*For girders and pillars of every water gate, hard granite was used to fulfil the necessity of required lengths.

・ Water gates made of stone, brick and concrete in Kojima reclaimed land in Okayama Prefecture

*For girders and pillars of every water gate, hard granite was used to fulfil the necessity of required lengths.

Modern times

・ Water gates made of tataki in Aichi Prefecture

*Tataki structure here is made by mixing lime and water with fine granules of weathered granite, kneading, and squeezing. It was designed by Choshichi Hattori (1840–1919). These fine granules are called 'Masado'.

Fig. 16: Sluice gate in Yatsushiro Polder (Kumamoto Pref.). © *Kazuyuki Yano.*

3.2.6. Group of cylindrical diversion works

Present time

・ Cylindrical diversion works on the West *Tenryu* main waterway in Nagano Prefecture, cf. 3-4 *System*

・ Cylindrical diversion works in Kurobe Plain in Toyama Prefecture

3.3. Network

	Function		Ancient Times	Early Modern Times	Modern Times
Network			Canal & River	・Canal Network ・Boat Transport & River Port using River & Canals ・Raft Floating & Timber Pond using River	・River & Canal Network ・Boat Transport & River Port using River & Canals ・Raft Floating & Timber Pond using River

Fig. 17: Water network. © *Takashi Itoh.*

Early modern times

・ Boat transport network between Kyoto and Osaka Prefectures using rivers and waterways through Oguraike Pond, the Yodogawa River and moats of Osaka Castle

Early modern to modern times

・ Waterways and creek irrigation in Saga Plain, and Yanagawa Canal network around the Chikugo River in Saga and Fukuoka Prefectures

Fig. 18: Yanagawa (Fukuoka Pref.) – The scenery of a creek and the castle's moat. © *Kazuyuki Yano.*

3.4. System

3.4.1. Lake Biwa in Shiga Prefecture, and Kyoto and Osaka Prefectures

	Function		Ancient Times	Early Modern Times	Modern Times
System	City			・Boat Transport & Flood Control by Kyoto Town, Oguraike Pond, the Yodo River and the Moats and Canals of Osaka Castle & Town ・Boat Transport by Moats, Canals and River of Matsue Castle & Town	・Water Supply Facilities, Sewerage Facilities ・Boat Transport & Recreation

Fig. 19: Water system in cities through time. © *Takashi Itoh.*

Early modern times

・ Boat transportation, irrigation and flood control: Rivers, waterways and ponds, etc. in Kyoto Town – Harbour in Oguraike Pond in Kyoto Prefecture -– the Yodogawa River – Osaka Castle and Castle Town in Osaka Prefecture

Modern Times

・ Lake Biwa in Shiga Prefecture – Lake Biwa Canal – Suirokaku Waterway, water supply facilities, Keage power plant, garden water and boat transportation in Kyoto City

3.4.2. Toyama Prefecture

	Function	Ancient Times	Early Modern Times	Modern Times
System	Catchment Basin			・Water Supply Dams, Flood Control Dams, Agricultural Waterway & City ・Sabo, Entrance of Waterways, Waterway Power Plant & City

Fig. 20: Catchment basin. © *Takashi Itoh*.

Early modern times

・ Irrigation network of the Joganji

River in Toyama Plain

Modern times to present time

・ Mountainside Sabo – Shiraiwa and other Sabo Dams -– Junction of irrigation waterways – irrigation waterways network and waterways power plants

・ Dams and power plant facilities of the Kurobe River in Toyama Prefecture

3.4.3. Irrigation waterways and water gates, cf. 3-2 (5) water gates

Early modern to modern times

・ Water gates made of stone, brick and tataki (finished by mixing lime and water with weathered fine granules of granite, kneading, and squeezing) in Yatsushiro reclaimed land in Kumamoto Prefecture

・ Water gates made of stone, brick and concrete in Kojima reclaimed land in Okayama Prefecture

Modern times

・ Water gates made of tataki in Aichi Prefecture

3.4.4. Water and cylindrical diversion works, cf. 3-2 (6) group of cylindrical diversion works

	Function		**Ancient Times**	**Early Modern Times**	**Modern Times**
System	Region		・Sayamike Pond & Waterways ・Mannouike Pond & Waterways	・Creek Waterways in Saga Plane & Canals at Yanagawa ・Paddy Field Waterways at various places	・Cylindrical Diversion Works, Waterways & Paddy Fields 6) ・Paddy Field Waterways at various places ・Dams & Power Plants7) ・Water Supply Dams, Flood Control Dams & City

Fig. 21: Water systems in regions. © *Takashi Itoh.*

Present time

・ Cylindrical diversion works on the West Tenryu Main Waterway in Nagano Prefecture:[6)] The fan in the Ina Basin formed on the right bank of the Tenryu River had poor water retention and was not suitable for paddy fields. Therefore, a main waterway, a group of cylindrical diversion works (105 places), and a network of irrigation waterways were constructed and transformed the Ina Basin into a granary.

・ Cylinder diversion works and irrigation waterways in Kurobe Plain in Toyama Prefecture

* Water is partly used after power generation.

3.4.5. Yawata steel works and Industrial water

Modern times to present time

・ The Onga River Pumping Station -- Reservoir – Steel plant cooling water

・ Kawachi Reservoir (including Minamikawachi Bridge and Kawachi Five Bridges) -- Steel plant cooling water

・ Onagohata dams and power plants – steel plant cooling water

3.4.6. The Kiso River power generation facilities[7)]

Modern times to present time

In the Kiso River water system, 31 power plants are currently in operation, from the Miura power plant on the upstream side to the Imawatari power plant on the downstream side. At each power plant, electricity is produced and transmitted, and the water after power generation is sent to downstream power plants one after another. In a way, this system also reduces the flow of the river.

Note: 1. Titles of the case in italic letters indicate that they are related to other cases. The italicized titles with cf. are attached to show the related cases.

2. The underlined items with the numbers 1)-7) are good representative cases of the corresponding items in different tables.

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Fig. 22: Covered bridge (Ehime Pref.). A bridge for supporting life in mountainous regions. © *Kazuyuki Yano.*

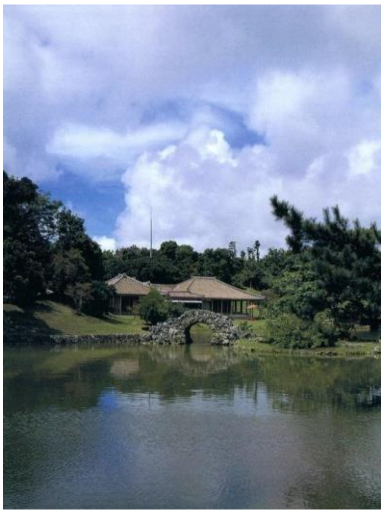

Fig. 23: Shikinaen – (Okinawa Pref.) A landscape garden where the culture of Ryukyu, Japan and China are fused. © *Kazuyuki Yano.*

Fig. 24: Wasabi farm (Shizuoka Pref.) – Wasabi farm that is supported by spring water. © *Kazuyuki Yano.*

Fig. 25: Lotus farm (Chiba Pref.). © *Kazuyuki Yano.*

Fig. 26: Junsai pond (Akita Pref.) – Junsai – (water shield aquatic plant) farm. © *Kazuyuki Yano.*

Fig. 27: Mogami River (Yamagata Pref.) Rivers that have supported rice farming and distribution. © *Kazuyuki Yano.*

Fig. 28: Daimyo Garden (Gunma Pref.) – landscape garden that is nurtured by Samurai culture. © *Kazuyuki Yano.*

Fig. 29: Shibai-zeki (Kagoshima Pref.) – a dam made with tree branches. © *Kazuyuki Yano.*

Case study: Aqueduct and hydraulic system of Tsujun irrigation canal (Kyushu, Japan)

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Introduction

The Tsujun irrigation canal was constructed in 1854 to supply water to the Shiraito Plateau in the Yabe commune of the Higo clan (today's Kumamoto prefecture, located in the middle of Kyushu Island). It has a mountainous geography and is surrounded by rivers. Farmers of this plateau had to go down to the rivers to obtain water for agricultural and domestic purposes. This lack of water led to a deterioration in rice field productivity, and farmers had to leave for other communes to make a living. The irrigation project was planned and realised to solve this problem (Fig. 1).

Fig. 1: Rice fields of the Shiraito Plateau © *Yasuhiro Honda.*

The irrigation network consists of two main canals. One is called 'Uwa-ide (upper canal),' which runs along the higher contours of the plateau. The other is called 'Shita-ide (lower canal),' which runs through the lower contour. Water for the upper canal is taken by a head work built across the Sasahara River, approximately 6 km north of the plateau; this then crosses a valley of more than 20 m depth via Tsujunkyo constructed in 1854, the largest masonry aqueduct in Japan at that time. The lower canal begins at the Gorogataki River with a simple water intake built in the dike, which passes just under Tsujunkyo. Branch canals provide water from the two main canals to the rice fields. The total length of the main and branch canals is more than 40 km (Fig. 2).

According to statistical records, the completion of the canals increased the surface area of rice fields from 0.44 km^2 in 1810 to 0.72 km^2 in 1867. Furthermore, owing to the amelioration of rice fields, the production of rice tripled from 61 tons in 1810 to 175.5 tons in 1867. This significant change in productivity enabled farmers to make their living solely through agriculture.

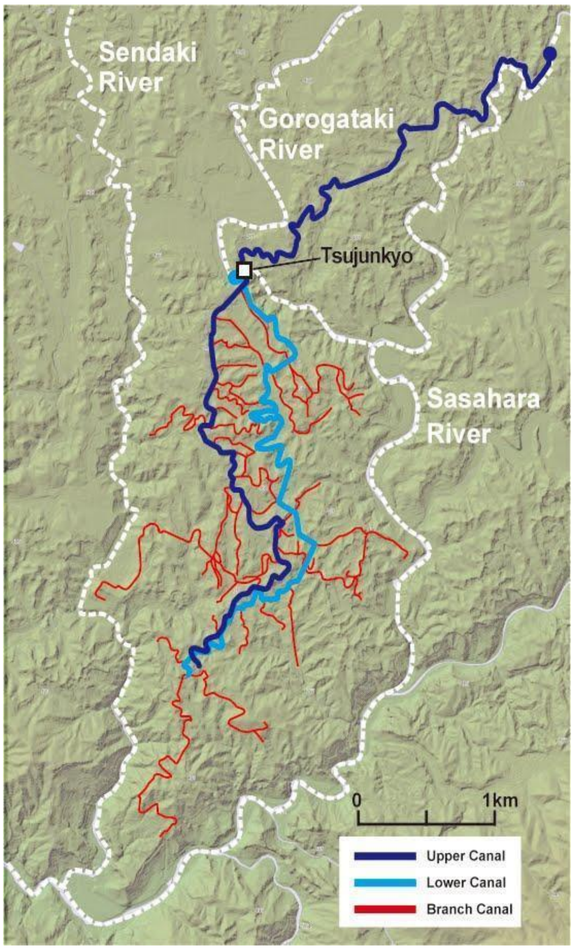

Fig. 2: Shiraito Plateau and irrigation canals (*Modified from Koga et al., 2010).*

1. Tsujunkyo Aqueduct

The most remarkable realisation of this irrigation project is the Tsujunkyo Aqueduct Bridge. Its arch span is 27.54 m., and its total length is 75.60 m. This single-span arch bridge is one of the largest masonry bridges in Japan of that era. Kyushu Island is almost the only region where masonry arch bridges were traditionally constructed in Japan, and it must have offered technical possibilities for the project. Furthermore, Higo Clan's commune-centered administrative system and the existence of a habile mason group were also key factors in this

Fig. 3: Tsujunkyo Aqueduct Bridge showing its spectacular water discharge. The Shiraito Plateau forms the background of the aqueduct. © *Yasuhiro Honda*

realisation. For technical reasons, the height of the bridge was limited to 20 m, which is insufficient for the adequate transfer of irrigation water over the valley. To solve this technical question, the siphon principle was employed. Brought to the entrance of the aqueduct, the irrigation water descended 7.5 m with a triple row of stone pipes and then was made to move upwards 5.8 m at the end of the aqueduct (Fig. 3).

2. Efficient use of irrigation water

Fig. 4: Spillway made with original materials. © *Yasuhiro Honda.*

Some technical devices were introduced to utilise the irrigation water. The two main canal systems (upper and lower canals) were underlined as a unique idea to make the best use of irrigation water. The irrigation water distributed from the upper canal passed the rice fields. In general, the surplus water was discharged, but in this case, the lower canal received the overflow and redistributed it to other rice fields.

A bunsui-bako is a wooden joint between the main and branch canals. A rectangular pipe is used for an appropriate distribution, and its inner dimension is determined by the surface area of the rice field to be irrigated. For example, a box called 'Ichiban-nuki (the first joint),' which sends 0.9 L. per second of water for a rice field of 0.12 ha, has inner dimensions of 10 cm × 8.4 cm. Presently, all 29 boxes have been replaced by polyvinyl pipes.

To protect the rice fields from canal floodwater caused by heavy rainfall, 55 spillways were installed. Each one comprised a gate with a stone frame and a wooden board that controlled the amount of water flow (Fig. 4). Almost all of them have been replaced by either a tilting weir or shutter gate.

Fig. 5: Circular tank diversion. © *Yasuhiro Honda.*

The construction of the Tsujun irrigation canal improved the situation of the Shiraito Plateau. Simultaneously, it created water rights' disputes with another village that used irrigation water from the same river of the upper canal. In 1956, over 100 years after the construction of the canals, a circular tank diversion was built to fix the water distribution ratio thereby completely resolving the dispute (Fig. 5).

3. Maintenance

Preventing sediment deposition is an important factor in the maintenance of canals. The technical devices indicate that farmers were empirically aware of hydraulic characteristics and intentionally controlled sediment deposition.

'Dorozen-nuki' is a wide section of the canal. By enlarging the cross-sectional area, the flow velocity deceleration results in sediment deposition in this section. Farmers have to dredge these sections intensively for maintenance.

It is also remarkable that the cross-sectional area of tunnels is relatively smaller than the open channel areas of this canal network. The increment in flow velocity makes it easier to sweep away the sediments carried from upstream. According to the association, dredging operations in tunnels have never been required to date.

People concerned with the Tsujunkyo Aqueduct were careful enough to prepare a countermeasure against the sediment problem. The water injection, which is the most impressive feature of the Tsujunkyo, was originally built to wash away the stone pipe sediment, where maintenance was difficult (Fig. 3).

The irrigation association organised by the clan around 1854 has been fully responsible for the efficient functioning of the irrigation system for over 150 years. Although the main body of the association has gradually changed (from prefecture to association), the farmers oversaw everyday patrols, maintenance, and restoration of irrigation canal devices. Moreover, the role of the person in charge of water distribution is considered important, and the position is occupied through hereditary succession. Children learned what and how to do it from their parents as well as by participating in and hearing the discussions in the periodic association meetings. This is one of the typical aspects of knowledge transfer from one generation to another that continues until today.

Conclusion

The Tsujunkyo Aqueduct bridge was inscribed on the list of nationally important cultural property in 1960 for its beautiful appearance and its large-scale realisation with the stone pipe siphon technique. In addition, 'Tsūjun Irrigation Canal and Rice Terrace Landscape of the Shiraito Tableland' has been maintained based on techniques and association as well as through daily residential life, as elaborated on the list of the national important cultural landscapes in 2008. Despite these legal protection mechanisms, the municipality is faced with a lack of successors that has resulted in a decrease in rice fields.

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04. China: General overview

Cultural heritages of water management in tropical and subtropical regions of China

By Wang Yinghua; Yang Bangde; Jiang Rui; Geng Tao; Guo Na; Xu Zhaoping; Li Haijing

1. General characteristics

1.1. General climatic data and general hydrological data

China's tropical and subtropical regions are mainly located to the south of the Huaihe River-Qinling Mountains line, which can be divided into three regions geographically: the middle and lower reaches of the Yangtze River, the southeast coastal region and southwest China.

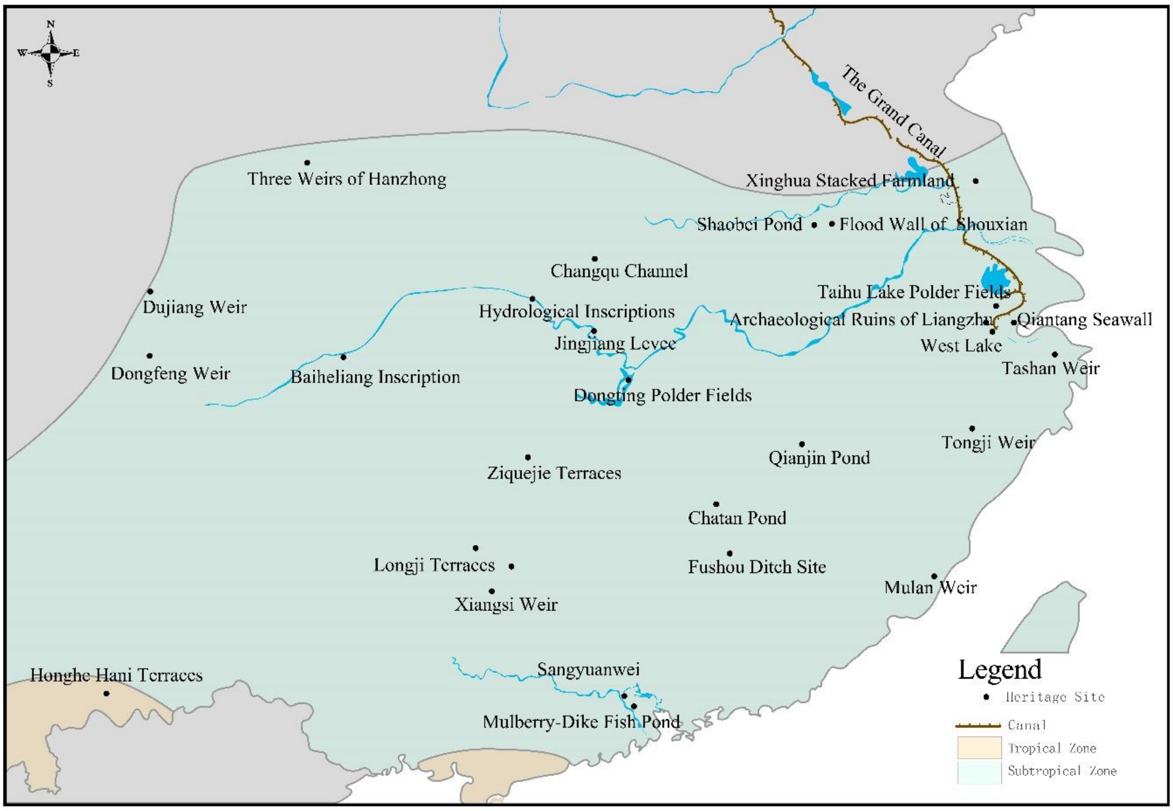

Fig. 1: Schematic diagram of the distribution of water heritage in tropical and subtropical areas of China (The region in the figure is not the complete extent) © *Zhang Nianqiang*.

The middle and lower reaches of the Yangtze River mainly include seven provinces and the cities of Hubei, Hunan, Anhui, Jiangxi, Zhejiang, Jiangsu and Shanghai, with an area of about 890,000 km². The terrain in this area is high in the west and low in the east, with low mountains and hills alternating with plains. The climate is warm in winter and hot in summer, with an annual average temperature of 13–20℃. The average annual precipitation is generally 800–1600 mm, and the distribution of precipitation decreases from southeast to northwest. The terrain also has a significant impact on precipitation. The annual distribution of rainfall is uneven; the regional distribution difference and interannual variation are large. The region has dense river networks, numerous lakes and abundant water resources. The Yangtze River, China's largest river, runs through the whole region. The Grand Canal, the longest artificial canal, runs through the eastern coast. It also includes the Huaihe River, Taihu Lake, Qiantang River, Minjiang River and other water systems. The rivers that originated in the mountainous regions of western Zhejiang are short and mostly flow into the sea alone, with Qiantang River as the largest. This region is also one of the regions with the largest concentration of lakes in China, including China's five largest freshwater lakes (Poyang Lake, Dongting Lake, Hongze Lake, Taihu Lake and Chaohu Lake).

Southeast coastal regions include Fujian Province, Guangdong Province, Hainan Province, Taiwan Region, Hong Kong Special Administrative Region and Macao Special Administrative Region, with an area of about 376,000 km². This region is located on the southeast coast, backed by the hinterland of the mainland and facing the Pacific Ocean. The coastline of the mainland is about 9,360 kilometres long, with numerous islands. The terrain is mainly mountainous and hilly. Larger plains include the Pearl River Delta, Hanjiang Delta and Western Taiwan Plain. Due to more mountains and less flat land, the per capita cultivated land area in this region is less. The annual average temperature of it is 17-27℃, and the annual precipitation of most areas is 1400–2000 mm, which is the most abundant rainfall of any area in China. Taiwan's Keelung Huoshaoliao has an average annual rainfall of 6,489 mm, with the highest annual rainfall reaching 8,409 mm. The spatial and temporal distribution of rainfall is not uniform. The amount of rainfall in coastal areas and islands is less than that in inland areas, and that in the plains is less than in mountainous areas. Typhoons are frequent in this region, with 80 per cent of the typhoons that hit China landing from this region. Typhoons brought abundant precipitation, but also storms, which led to frequent floods. The rivers in this region are mostly mountainous rivers, and the river run-off mainly depends on rainwater supply, so the run-off characteristics are basically consistent with the precipitation characteristics.

Southwest China is mainly composed of Chongqing, Sichuan, Yunnan, Guizhou and Guangxi provinces, covering an area of 1376,900 km², inhabited by more than 40 ethnic groups. The region is located on the eastern side of the Qinghai-Tibet Plateau and occupies a small part of each of China's three major land ladders. The vertical differentiation of natural landscape is significant, with the terrain higher in the west and lower in the east, and higher in the north and lower in the south. The temperature in this region is higher and the heat condition is better. The average annual temperature in most areas is between 14 and 24℃, but the spatial distribution is more complex. The region is rich in precipitation, and its spatial distribution is obviously decreasing from southeast to northwest. Changes in altitude and slope direction also cause local differences in precipitation. The river network in this region is dense with many rivers, which are mainly divided into the Yellow River, Yangtze River, Irrawaddy River, Nujiang River, Lancang River, Yuanjiang River and Pearl River. Most of the big rivers are transit rivers, including many international rivers. The longitudinal gradient of the riverbed is large, and the longitudinal sections are often twisting. Some rivers in Sichuan Basin and Guangxi Basin have well developed meanders. Blind valleys and hidden rivers are common in karst areas of Yunnan Guizhou Plateau. The proportion of rainwater recharge in most rivers exceeds 70 per cent of annual run-off. Groundwater recharge in Yunnan-Guizhou Plateau is the highest, generally accounting for 30 per cent of annual run-off. Ice and snow melt water supply is limited to rivers in Hengduan Mountains. River run-off varies greatly between high and low water years, with seasonal distribution as uneven as precipitation and large interannual variation.

1.2 Cultural relations and technical exchanges with neighbouring zones

The development of water conservancy in China's tropical and subtropical regions not only stems from its own unique natural geography and hydrology and water resource conditions, and from the unique needs of local economic and social development, but it is also closely related to the transfer of economic centres and cultural exchanges between the south and the north in China's historical period.

Since the establishment of the Qin Dynasty (221 BC–206 BC), there have been two phenomena in Chinese history: one was the alternation of unification and division. Second, the economic centre moved southward from the middle reaches of the Yellow River to the Yangtze River. During the period of division, a large number of people would migrate from relatively developed areas to relatively stable areas, bringing not only human and financial resources, but also advanced technology. The rulers of these regions would also attach great importance to agricultural development and transportation in the region, thus enhancing the national strength, gaining advantages from the war, and even eventually unifying the country. Against this background, water conservancy, management and control in this area began to develop gradually.

The development of the tropical and subtropical regions of China benefited from three stages: first, the Eastern Han Dynasty to the Southern and Northern Dynasties (220–589 AD). This was China's first period of division, with frequent wars in the north and a large number of people migrating southward. The advanced technology they brought promoted the development of irrigation and flood control in southern China, enabling the development of the Huaihe River Basin. The second period – the Sui and Tang Dynasties – was the second period of unification and peace in China (581–907 AD). During this period, the Yangtze River Basin achieved the status of China's economic centre and the Grand Canal also developed rapidly, thus connecting the capital with the economic centre. The third was the Five Dynasties and Ten Countries and the Song Dynasty, which was the second period of division and struggle in China (907–1297 AD). During this period, the Yangtze River Basin, as China's prominent economic centre, was further fully developed. Water control and management of this basin was a key issue of the development during that time.

There is also a transfer of water conservancy engineering technology in this region. In 600 BC, large-scale pond projects first appeared in the Huaihe River basin, among which Shaobei Pond is the most representative and still irrigates 4,2000 hectares of farmland. By the time of the Eastern Han Dynasty (25–220 AD), it further developed into the Yangtze River Basin, then further developed southward, and gradually became the main type of irrigation and water conservancy in the region. The construction technology of polder fields originated from Taihu Lake region in the Spring and Autumn Period, but its development has been slow. During the Tang and Song Dynasties (618–1279 AD) with the southward movement of China's economic centre and the progress of production tools, different types of polder water conservancy were gradually formed, including polders in west Zhejiang, in east Zhejiang, and in Guangdong.

2. Known sites and important sites for the cultural heritage of water

2.1. Archaeological sites

Archaeological excavation shows that in the middle and lower reaches of the Yangtze River more than 6,000 years ago, people began to use bone and stone tools to dig ditches, build bridges, drain water to reclaim land, and water for irrigation in low-lying areas. This was the start of irrigation and drainage engineering technology. However, the most famous archaeological site is the Archaeological Ruins of Liangzhu City (see Case study: The peripheral water conservancy system in the archaeological ruins of Liangzhu City) in Zhengjiang Province and the Baiheliang Inscription in Chongqing.

Located in the Yangtze River Basin on the south-eastern coast of China, the archaeological ruins of Liangzhu (about 3300–2300 BC) reveal an early regional state with a unified belief system based on rice cultivation in Late Neolithic China. The water engineering system discovered outside the archaeological ruins of Liangzhu City is the earliest example of large-scale water engineering in China and the earliest dam system in the world. The so-called dam should be a typical engineering form of weir in the mountain areas south of Yangtze River.

The peripheral water system of Liangzhu City includes weirs built in mountainous areas, weirs and dikes built in plains and the basin area, it controls and affects exceeds 100 km^2. Tianmu Mountain Range where Liangzhu City is located is the largest rainstorm centre in Zhejiang Province, and mountain torrents often break out every rainy season, which is still the case today. Liangzhu City is built on a highland, surrounded by mountains on three sides and facing Hangzhou-Jiaxing-Huzhou Plain in the east, with a dense water network, which is suitable for planting rice. In order to make better use of and manage water resources, the local people built six weirs at the mouth of the valley in the northwest of Liangzhu City to control the two rivers that originated from the mountainous areas, which are called 'high dams' because of their high terrain. They also built four weirs, called 'low dams', in the plain area in the west of Liangzhu city, and built two parallel dikes at the foot of the mountain in the north of Liangzhu city, with a length of 5 kilometres. The reservoir formed by 'low dams' and long dikes has a capacity of about 32.9 million cubic metres. The finally formed water engineering system integrating urban water use, mountain flood prevention, farmland irrigation, shipping and other functions, was an amazing feat of engineering when you consider it was developed more than 5,000 years ago. In 2019, it was selected as a world cultural heritage site.

Baiheliang Inscription is located on the underwater stone beam in the north of Fuling City, Chongqing, in the upper reaches of the Yangtze River. There are 165 inscriptions, of which 108 record the dry water level of the Yangtze River. Most of the water levels recorded in these inscriptions are measured by 'stone fish' as a water mark. There are 18 stone fish carved on the stone beam, of which only 3 play the role of marking the water level of the Yangtze River. One is the stone fish carved before the second year of Guangde (764 AD) of the Tang Dynasty, which is also the earliest stone fish found so far. It is located in the middle of the area where the inscriptions are concentrated; the other two were carved in 1685, slightly higher than the stone fish in the Tang Dynasty, as if they were swimming upstream one after another. Local people take the stone fish's eyes as the standard point to measure the water level of the Yangtze River. Every time the stone fish comes out of the water, the stone carving is used to record the time when the stone fish comes out of the water and the distance between the stone fish and the dry water line, which is gradually accumulated into the dry water level data series of the Yangtze River. These inscriptions and images, with a total of 30,000 words, have recorded the historical dry water level of 72 years in the middle and upper reaches of the Yangtze River for more than 1,200 years intermittently, which is of great historical value for studying the law of dry water, shipping and agricultural production in these areas. During the construction of the Three Gorges project, a famous underwater museum was built here to protect these precious hydrological records.

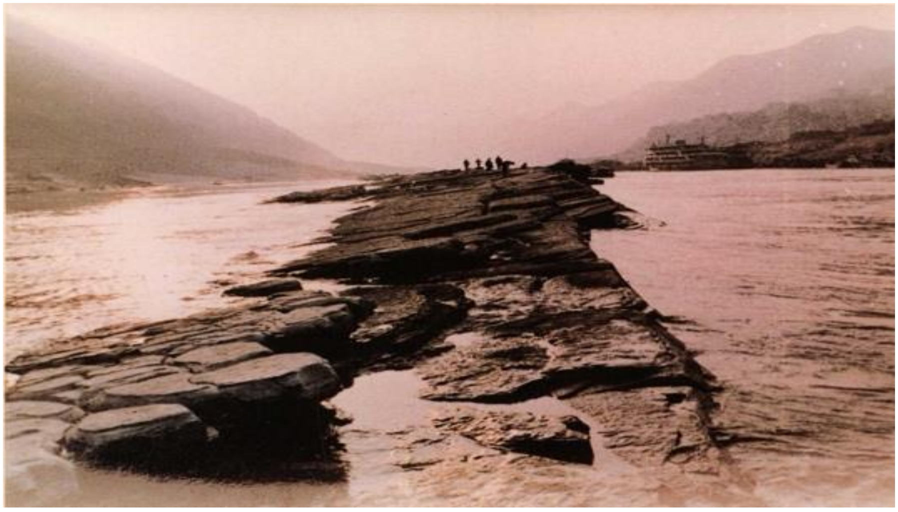

Fig. 2 Baiheliang Inscription from Hydrologic Inscription Cultural Relics in Three Gorges Reservoir Area.

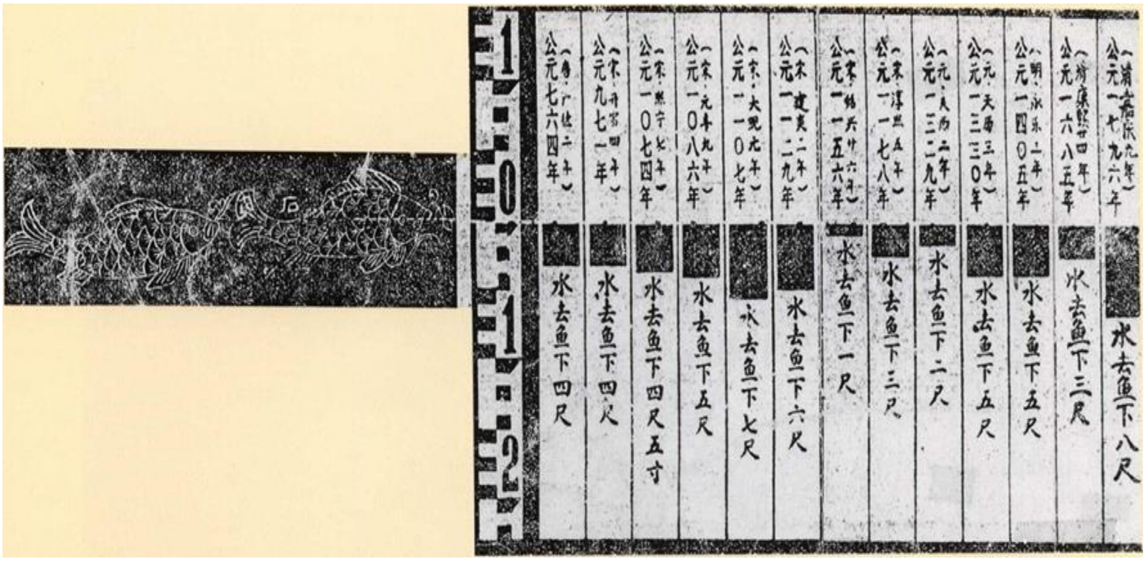

Fig. 3: Schematic diagram of the relationship between stone fish and inscribed water level. From Hydrologic Inscription Cultural Relics in Three Gorges Reservoir Area.

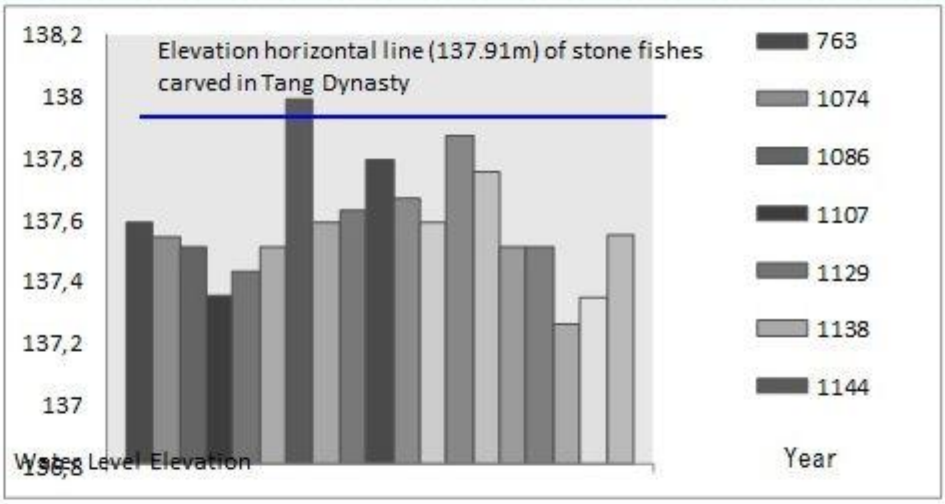

Fig. 4. Schematic diagram of the change of water level elevation of Baiheliang recorded from 634 to 1963.

2.2 Living sites

2.2.1 Water acquisition, management and control

The ancient water conservancy achievements in the tropical and subtropical regions of China are not only reflected in the development level of water conservancy engineering technology, but also in the management level. In China's thousands of years of water conservancy construction practice, rich experience in water conservancy construction and operation management has been accumulated, and many are still worthy of discussion and reference.

As early as in the Three Kingdoms up to the Sui and Tang Dynasties, flood control management was gradually on the right track. The dike protection order issued by Zhuge Liang (181–234 AD), the Prime Minister of Shu state during the Three Kingdoms period, is the earliest flood control management law. At the latest in the Song Dynasty (960–1279 AD), there were strict norms for the management of construction quota, which clearly stipulated the calculation method of labour quota of various types of work in earthworks. Therefore, although the ancient dike engineering construction scale is large, the organisation is very tight. After the completion of the dike, there was a strict annual maintenance management system and a set of measures for flood control, so that the operation of the dike was as safe and effective as possible. The annual repair system and flood control system created by Pan Jixun (1521–1595 AD), a famous water expert in the Ming Dynasty, are representative of ancient dike management norms.

During the Tang, Song and Yuan Dynasties, with the development of irrigation engineering, the rules and regulations of irrigation management were gradually improved from top to bottom. A lot of experience was accumulated in the areas of organisation, engineering maintenance, water distribution, funds and labour force, and the characteristic irrigation management system was formed in various regions. With the promulgation and implementation of the Water Law of the Tang Dynasty and the Treaty of Farmland and Water Conservancy of the Song Dynasty, many irrigation areas in China's tropical and subtropical regions formed their own irrigation management systems with local characteristics. Some of them formed scientific principles by summarising, deepening, perfecting and refining in the past dynasties. For example, in the management of Dujiang Weir strict and scientific management systems, such as 'taking advantage of the situation to guide and adjust measures to the time' and 'It should be deep when scouring the beach and low when building the weir' were gradually formed, and these have enabled it to operate for more than 2000 years. In the Song Dynasty, Shanhe weir irrigation area in Hanzhong, Shaanxi Province formed the management system of canal system water distribution and engineering maintenance. It stipulates that the water consumption should be distributed according to the size of farmland area, and the distribution should be controlled by gates at all levels, and the production specifications of gates at all levels also have provisions, so as to avoid water disputes. In this irrigation area, it is also stipulated that the weir and channel should be maintained every year, and the amount of maintenance should be allocated according to the amount of farmland benefited of by farmers. In 1168, there were as many as 20 regulations for the management of Tongji Weir in Lishui County, Zhejiang Province. The detailed regulations were praised by later generations. This regulation mainly implements the spirit of self-management of the local people in the irrigation area, and the government does not intervene too much; it stipulates the generation method of the management organisation of the irrigation area, clarifies the responsibilities of the management personnel at all levels, and has strict punishment clauses to restrict it. It adheres to the regular maintenance system for various engineering facilities in the irrigation area, and regularly cleans up and down. The water use system of the irrigation area requires that the interests of farmers in the upper, middle and lower sections should be balanced, and upstream influence on the downstream water consumption is not allowed. Since then, although the specific contents of weir regulations have been revised, the basic principles have not changed.

In terms of canal engineering management, a relatively complete system was formulated in the Yuan Dynasty (1271–1368 AD), which had very detailed regulations on the opening and closing of gates, procedures for fleets passing through the locks, the maintenance of canals and requirements for the size of vessels. In order to meet the requirements of water transport, the canal project operation, maintenance and management system were relatively better implemented.

In the early days of China, there were only officials and no special water conservancy management institutions. Water conservancy officials were established in the Western Zhou Dynasty (1046–771 BC), mainly responsible for the construction and management of flood control projects. In the Qin and Han Dynasties (221 BC–220 AD), with the establishment of the state official system, water conservancy management institutions were set up in the central and local official systems respectively. Since then, the names of water conservancy institutions and water conservancy officials have changed many times, but there are always special institutions and officials to manage. During the song and Yuan Dynasties (960–1368 AD), the scope of responsibilities and management authority of water conservancy management institutions were constantly expanded, and at the same time, a supervision organisation was set up in the central government to supervise the construction of water conservancy projects. In the Ming and Qing Dynasties, similar institutions of river basin management, namely River Governor, began to appear, and the water management system from the central to the local gradually improved.

2.2.2 Irrigation and drainage engineering

The diversity of topography, the complexity of hydrological and the water resources' conditions, the different needs of social and economic development, and the regional and national cultural differences in China's tropical and subtropical regions have formed many different types of heritage irrigation projects in the long history of water conservancy development. Among them, there is one world heritage site, Dujiang Irrigation System in Sichuan Province (*See also Case Study: Dujiangyan Irrigation System*), and more than 10 world irrigation engineering heritages, such as Shaobei pond in Shouxian County, Anhui Province and Tongji Weir in Lishui, Zhejiang Province.

Large-scale irrigation channel technology came into being more than 2,000 years ago, and Dujiang Weir is the most typical one in this region. The canal head was built at the top of the alluvial fan of the main stream of the Minjiang River, occupying a favourable geographical position, which could meet the needs of gravity irrigation throughout Chengdu Plain. The canal head hub of it consists of three main projects: Fish Mouth (water diversion dike), Flying Sand Weir (overflow weir) and Bottle Mouth (water intake). They have a reasonable layout and unique functions, and jointly play an important role in diversion, flood discharge and sediment discharge. Fish Mouth is located in the centre of Minjiang River, and divides Minjiang River into Inner River and Outer River. The Outer River is in the west, which is the positive current of Minjiang River and is mainly used for flood discharge and sediment discharge. The Inner River is in the east and is the main water diversion channel. It enters Chengdu Plain through Bottle Mouth. It makes use of the topography to divide Minjiang River water in proportion. In the dry season, the water level of Minjiang River is low, and the mainstream line of the river is mostly close to the concave bank. Flying Sand Weir will take about 6/10 of the river water into the Inner River to ensure the water consumption of the irrigation area. When the flood comes, the water level of Minjiang River rises, and the mainstream becomes relatively straight and flows to the convex bank. Flying Sand Weir discharges about six-tenths of the river water into the Outer River, and at the same time takes away most of the sand and gravel. Flying Sand Weir is the channel of flood discharge and sediment discharge in the Inner River, which discharges the river water exceeding the irrigation need to the Outer River by itself. At the same time, centrifugal force is used to discharge a large amount of sand and gravel in the water to the Outer River. In the event of a catastrophic flood, Flying Sand Weir will burst on its own, allowing the river to return to the Minjiang River. Bottle Mouth is the water intake of irrigation area, with an average width of 20 metres. The Flying Sand Weir helps to ensure that the amount of water entering the Inner River not only meets the irrigation needs of Chengdu Plain, but also prevents too much of the flood waters from entering. It acts as the 'throat' and control the amount of water entering the Inner River. This system is 2,500 years old and still controls the waters of the Minjiang River and distributes it to the fertile farmland of the Chengdu plains.

Polder fields are typical irrigation projects in Taihu Plain, in the plains of the Middle and Lower Reaches of the Yangtze River and the Pearl River Delta. The middle and lower reaches of the Yangtze River Plain is the largest plain in tropical and subtropical regions of China. It has many rivers, many lakes and low-lying terrain, and is prone to flood disasters. The situation of the Pearl River Delta and Taihu Plain is similar. After the middle of the Tang Dynasty, with the rapid increase of population in southern China, the problem of insufficient cultivated land became increasingly serious. In addition to reclaiming barren mountains, people began to cultivate low-lying plains. To solve the problem of flood and waterlogging, people in these areas creatively invented polder field technology. Among them, the Taihu Plain was the most frequently constructed, followed by the Central Anhui Plain and the Pearl River Delta. Building of Dongting Lake Plain and Poyang Lake Plain in the middle reaches of the Yangtze River did not begin on a large scale until the Ming and Qing Dynasties. Taihu Lake is adjacent to the East China Sea in the east, the Yangtze River in the northeast, and mountains in the northwest and southwest. Its terrain is characterised by high surrounds and is low-lying in the middle, forming a dished depression centred on Taihu Lake. During the flood season, the water level of the outer river is often higher than the surface of the field, and the water inside cannot be drained. Floods are a great threat. In addition, it is also attacked by the high tide of the Yangtze River estuary and the coastal spring tide. Therefore, in the high field area of the Taihu Plain, it was necessary to dig channels for irrigation to solve the drought problem; in the low field area, embankments were built for flood control and drainage. Therefore, Tangpu polder field water conservancy came into being, and cooperated with Taihu Lake dike and seawall project to form a relatively complete Tangpu polder field water project system. Thus, Taihu Lougang engineering system in Huzhou, Zhejiang Province has been included in the ICID Register of World Heritage structures.

Fig. 5: Taihu Lougang Polder Fields in Huzhou County, Zhejiang Province, in 2019 © *Wei Jianguo, Wang Ying.*

Tide-Blocking and Freshwater Holding is a typical type of engineering in the southeast coastal plain area. The terrain here is flat, many rivers flowed into the sea, and the tidal difference was also large. The seawater often poured into the river, which caused salinisation of the local land. To solve this problem a special type of irrigation project was born, that is, through the construction of sluices and weirs, to retain the fresh water in the river from being discharged into the sea, and to prevent the sea water from flowing back into the river. This kind of engineering type originated in the Tang Dynasty (618–907 AD) at the latest and developed rapidly after the Song Dynasty (960–1279 AD). Among them, the most representative are Tashan Weir in Yinxian County, Zhejiang Province, and Mulan Weir in Putian, Fujian Province, both of which have been included in the International Commission on Irrigation & Drainage (ICID) Register of World Heritage Structures.

Figs. 6–7: Tashan Weir and its overflow dam, in 2019. © *Wei Jianguo / Wang Ying.*

Pond is the most common irrigation project in the hilly area of tropical and subtropical regions in China, and also accounts for the largest number of irrigation projects. In hilly or high-rise areas, surface water is easy to lose, drought is the biggest threat to agricultural production in these areas; if the rainfall is slightly heavy, mountain torrents occur easily. After the Qin and Han Dynasties (221 BC–220 AD), a large number of ponds, which were water storage projects, were built and were mainly composed of water retaining, discharging, water intake structures and a reservoir area. It is mainly used to solve the contradiction of time distribution and water level elevation between incoming water and water use, so as to make better use of water resources. Some of them make use of the favourable topography of the depressions around the mountains to form ponds by building long dikes; some built dikes at the mouth of valleys or where water from highlands gathered to form ponds; others built weirs and dams on valleys and streams to retain river water. Many ponds, such as Tongji Weir in Lishui, Zhejiang Province and Huangqu in Fujian Province, which have been included in the ICID Register of World Heritage Structure, are of this type.

The large-scale water-holding pond is a unique type of pond, mainly distributed in the south of Huaihe River and Hanshui River Basin. In order to make full use of water resources and allocate water on a larger scale, people here creatively adopt the engineering type of connecting the big and small ponds by digging channels, so as to form a large irrigation network. Compared with the small pond, which is only used for water storage, because of the excavation of the water conveyance channel, it has the characteristics of long water supply time and uniform flow, which functions as an irrigation channel, but it also functions as a water supply and supports shipping. Because the water conveyance channel is like a 'long vine', and the large and small ponds connected together are like melons on the long vine, this type of project is also called 'long vine with melons' engineering system. Quebei Pond is an example of this and has been included in the ICID Register of World Heritage Structures.

Fig.8: Honghe Hani Terraces, in 2018. © *Zheng Yubao*.

Terrace fields are mainly distributed in the mountainous areas of the south of the Yangtze River, most of which are in Guangxi and Yunnan. They are constructed along the contour line in sections on the sloping land. It is an effective measure to control soil and water loss of slope farmland and has been developed for more than 2000 years. According to the different slope of field surface, terrace mainly includes horizontal slope and compound terraces. Among them, Honghe Hani Terrace in Yunyang County, Yunnan Province is more representative. It is a three-dimensional terrace system, which consists of four main elements: (1) The water conservation forest at the top of the mountain (mostly over 1,800 metres), which is the water source of the terrace system, provides drinking water for people or livestock in villages and irrigation water for rice planting in terraced fields; (2) Villages under the forest (1500 m–1800 m). The altitude and temperature here are suitable for human habitation, and it is located below the water source and above the farmland, which is convenient for the management of irrigation water and the development of agricultural activities. (3) Terrace below the village (700 m–1800 m). And the altitude and temperature are suitable for the cultivation of traditional rice (Red rice instead of traditional rice). (4) The water under the terraced fields (Red River). The remarkable features of this system can be summarised as follows: under the good management of local people, forests can provide water for rice planting, while terraces can feed people (Wang, 1999). The cultural landscape of Honghe Hani Rice Terraces (*See also Case study: Water heritage of Hani Rice Terraces, with a special focus on World Heritage property*), has been included in the World Heritage List, and Ziquejie terrace has been included in the ICID Register of World Heritage Structures.

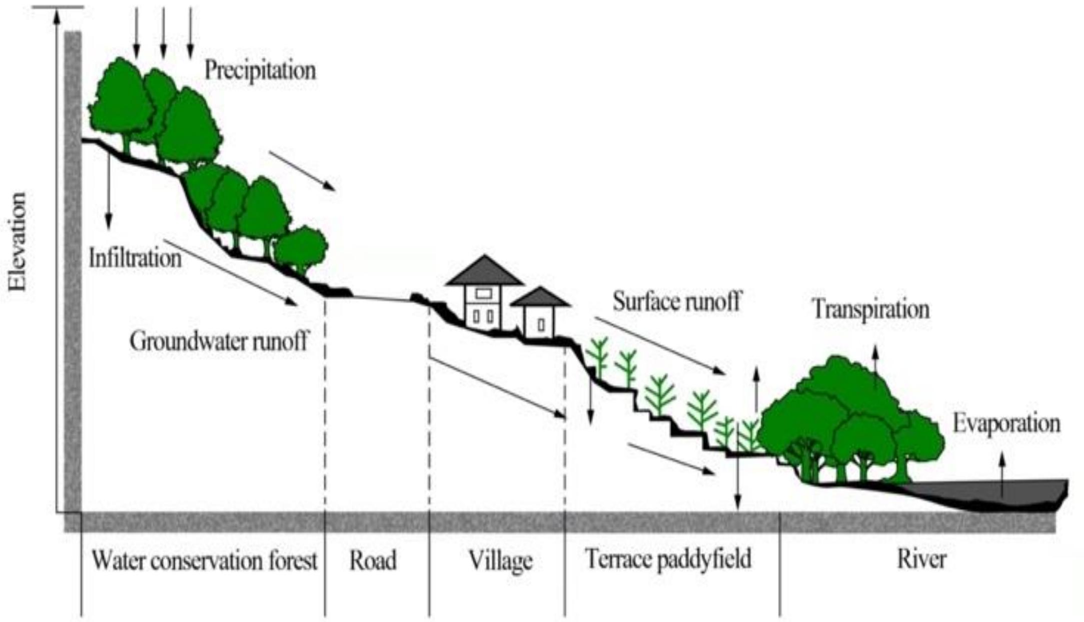

Fig. 9: Schematic diagram of spatial structure of Honghe Hani Terraces.

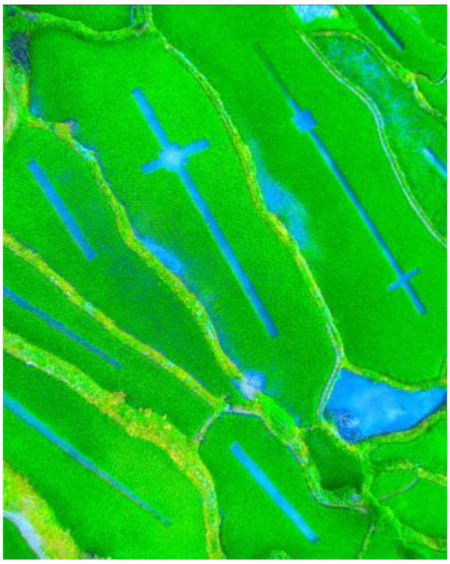

Fig. 10: The ditch used for raising fish in terrace fields, in 2018. © *Zheng Yubao.*

Fig. 11: The huts used as well houses in terrace fields, in 2018. © *Zheng Yubao.*

Stacked farmland (Duotian) is a unique land use and agricultural landscape in Xinghua County, Jiangsu Province. When local people dig deep ditches or small rivers in lakes and marshes, they pile up the excavated soil and then cultivate on it, so as to form this type of farmland. Stacked farmland in Xinghua area appeared in the middle of Ming Dynasty and the early period of Qing Dynasty. This was because during 1128-1855, the Yellow River occupied the Huaihe River course, and the lower reaches of the Huaihe River gradually silted up. During the flood season, it was difficult for the Huaihe River to enter the sea, so it had to turn to Lixiahe River Area for flood discharge. Lixiahe area is high around and low in the middle, of which Xinghua County is the lowest, so floods and perennial waterlogging often occur. Therefore, people used this special geographical environment to create this special farming method. At present, more than 3200 hectares of stacked farmland are preserved in Xinghua, half of which are located in the town of Duotian, which is the best-preserved and most concentrated area.

Fig. 12: Stacked farmland in Xinghua, in 2019. *© Xu Xiaofeng.*

Plateau Lake engineering is mainly distributed in Yunnan-Guizhou Plateau, especially in Yunnan Plateau, where there are many lakes. The Ming and Qing Dynasties were the periods of large-scale development of plateau lakes, and the related engineering technology was greatly improved. Yunnan Dianchi engineering system is one of the most representative projects.

Generally speaking, most of these irrigation engineering heritages were created and built by local people in practice, and they adapted to the natural and geographical conditions of different places in practice. For example, the hilly areas south of the Yangtze River are dominated by water storage ponds and weirs, and the low-lying plain is dominated by water network and polder fields; the Yangtze Huaihe River region is located in the north-south transitional area, and more large-scale water-holding ponds have been built. These various types of irrigation engineering and their technology have been practiced for thousands of years and have strong and lasting vitality.

2.2.3. Water transportation engineering

The Grand Canal of China (*See also Regional Overview: The Grand Canal of China*) and Lingqu Canal are the most famous water transport engineering projects in tropical and subtropical regions of China. The former is included in the World Heritage List, and the latter is included in the Tentative List of World Heritage. The Grand Canal in tropical and subtropical regions mainly runs through Jiangsu, Zhejiang, Anhui and Henan provinces.

The Grand Canal is the largest canal engineering system in the world with the most complex natural conditions and the longest duration of operation. It plays an important role in China's national unity and stability, economic and social development and cultural prosperity. In more than 2,500 years, due to the great difference of natural conditions along the Grand Canal, the uneven distribution of water resources in time and space, and the continuous operation of successive dynasties, it gradually developed from the original interval canal which simply connected the natural rivers to form a complex giant system with the longest length of more than 2,000 kilometres, connecting five major water systems and spanning eight provinces. It almost concentrated various types of water projects in different historical periods, and gradually became an independent and complete engineering system. The sub-tropical section of the Grand Canal still plays an important role in water conservancy and municipal administration, such as transportation, flood discharge and water conveyance. As the Grand Canal formed and developed, ancient cities, towns and villages with distinctive characteristics of the times and regions evolved in parallel with it, this has resulted in a rich and colourful regional culture and created a variety of natural and cultural landscapes. It can be said that the Grand Canal focuses on the development and achievements of water science and technology in ancient China for a period of more than 2,500 years and shows the history and culture of different regions in different historical periods in the eastern plain of China, with rich accumulation and profound connotation.

Lingqu Canal is an artificial canal built by the Qin Empire for the purpose of unifying China. It connected the Yangtze River and the Pearl River for the first time.

2.2.4. Flood control engineering

Jingjiang Levee and Qiantang River Seawall are the most famous flood control projects in tropical and subtropical areas of China.

The Qiantang estuary, where the Qiantang River Seawall is located, has a trumpet shaped topography. There are sand ridges at the bottom of the estuary, and the cross section of the estuary shrinks sharply. As a result, the tide entering the Qiantang River is prone to produce a huge tidal level difference, forming a unique natural landscape, namely Qiantang River Tidal Bore. This kind of tidal bore is ferocious. The maximum tidal wave is 3 metres, and the tide speed is about 20 kilometres per hour. In typhoon season, the tide head can reach more than 8 metres. In order to prevent invasion of the tidal bore, systematic seawalls were gradually built in the estuary of Qiantang River and Hangzhou Bay. As early as the Han Dynasty (202BC–220 AD), there are records of building the Qiantang River Seawall. During the Sui, Tang and Song dynasties (581–1279 AD), Jiangnan area gradually became the national financial district, and systematic seawall projects were built in the coastal areas of Western Zhejiang. During the Ming and Qing dynasties (1368–1911 AD), there was rapid building of seawalls, the earth embankments were changed into stone embankments, and the seawall layout and structure were improved, so that the engineering system was more complete, and the engineering technology was greatly improved. These seawall projects are examples of one of the great construction projects in ancient China and still play an effective role.

The section of the Yangtze River from Zhicheng in Hubei Province to Chenglingji in Hunan Province is the Jingjiang River section. The river course is curved and narrow, and the water from Qingjiang River, Hanjiang River and Dongting Lake flows into the Yangtze River in this section. Most of the crevasses in the main stream of the Yangtze River occur here. Therefore, the construction of dikes on the north bank of Jingjiang River began very early. Up to now, a 182-kilometre long Jingjiang Levee has been formed from Zaolinggang in Jiangling County to the south of Jianli County. Jingjiang Levee is the safety guarantee of Jianghan Plain and an important dike section along the Yangtze River.

2.2.5. Urban water project

Without certain conditions of water resources, cities cannot be created; without the development and protection of urban water resources and without the construction of urban water conservancy, it is difficult for cities to exist and develop. The main contents of urban water conservancy in ancient China are urban water supply, urban flood control, urban traffic, suburban irrigation and urban landscape, which are generally consistent with the contents of modern urban water conservancy. The Classical

Gardens of Suzhou and the Old Town of Lijiang are good examples of ancient urban water landscape projects in tropical and subtropical areas of China, both of which have been included in the World Heritage List. The ancient city walls of Shouxian County in Anhui Province and Fushougou Ditch in Ganzhou County, Jiangxi Province, are examples of urban flood control projects.

The Classical Gardens of Suzhou have a long history which can be traced back to the construction of royal gardens in the state of Wu in the sixth century BC. The construction of private gardens began in the Eastern Jin Dynasty (1115–1234 AD) and flourished in the Song, Yuan, Ming and Qing Dynasties. In its heyday, there were more than 200 gardens in the city, and there are still more than 50. In 1997, the Classical Gardens of Suzhou, with the Humble Administrator Garden (Zhuozheng garden), Liuyuan Garden, Wangshiyuan Garden and Huanxiu Villa, were included in the World Heritage list as the expansion projects of Classical Gardens of Suzhou. In 2000, Canglang Pavilion, Shizilin, Yipu garden, Jueyuan garden and Tuisi Garden were included in the World Heritage List as the expansion projects of the Classical Gardens of Suzhou. These gardens endow water with soul and recreate the universe in a very small space. The Classical Gardens of Suzhou are recognised as a model to realise this design idea, reflecting the profound artistic conception of Chinese culture that follows nature and transcends nature.

The Old Town of Lijiang is located in Yunnan Province, located in the Yunnan-Guizhou Plateau, where many ethnic groups live. Because the Jinsha River flows through its territory, it is named Lijiang. From the Qinghai-Tibet Plateau, the Yangtze River rushes south along the Hengduan Mountains, and suddenly turns north after arriving at Shigu Town, forming the 'first bay of the Yangtze River' here. Yulong Snow Mountain and Haba Snow Mountain confront each other and squeeze the Jinsha River to form a frightening 'Tiger Leaping Gorge'. Nalu Lake and many plateau lakes are like Jasper inlaid in the green mountains and fields. The Old Town of Lijiang is built on the mountain. The houses here are made of green bricks, grey tiles and wooden frames. The main street is near the river, the alley is near the canal, and the bridge is in front of the gate. The clear spring water runs through the streets and lanes, giving the ancient city a beautiful poetic and picturesque flavour. In the Old town of Lijiang there is an ancient water supply system, which is crisscross, exquisite and unique, and still plays an effective role.

2.2.6. Fishery ecological engineering

The Mulberry Fish Pond is a production and management model, which is mainly found in the Yangtze River Delta and the Pearl River Delta Plain. Mulberry trees are planted on or near the banks of ponds to raise silkworms with mulberry leaves. The excrement of silkworms is used as food for fish and pond mud is used as fertiliser for the mulberry trees. In this way, a unique ecological chain is formed, fish and silkworm breeding are carried out together to achieve the goal of mutual utilisation and mutual promotion.

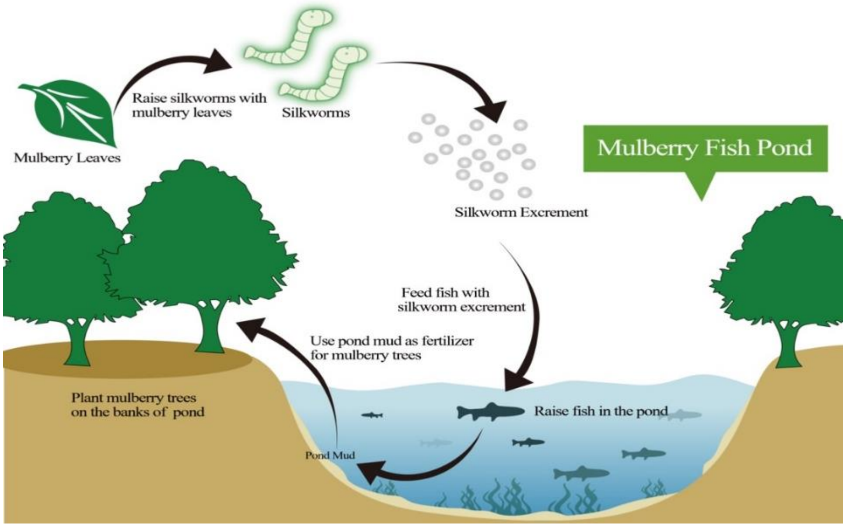

Fig.13: Schematic diagram of basic ecological principles of mulberry fish pond.

2.3. Cultural landscapes related to water

Water is not only a natural resource, with irrigation, shipping, flood control, power generation and other basic water conservancy functions, but it is also as a type of cultural resource, through which a unique and charming cultural landscape can be formed. The West Lake Cultural Landscape of Hangzhou is one of the most famous water cultural landscapes in China's tropical and subtropical regions, which have been included in the World Heritage List.

Hangzhou West Lake is a model of cultural landscape based on a large area of water and water projects and art design. It is famous for its beautiful lakes, mountains and many places of interest. It is an artificial reservoir built on a natural lagoon. It not only functions as urban water supply and ecological regulation, but it is also divided into five regions through Gushan, Bai dike and Su dike, forming a landscape pattern of 'lakes in lakes'. The combination of water engineering construction and landscape construction is the best interpretation of the ancient people to the ideal state of the unity of man and nature, and the combination of engineering and art.

Honghe Hani Rice Terraces (*See 2.2.2*) is also a a cultural landscape which shows the harmony between man and nature through the magnificent project and profound historical and cultural connotation, as well as the tenacious survival ability, great creativity and optimistic spirit of human beings under extreme natural conditions.

3. Existing documentation

In this area, the reference list mainly includes the World Heritage List, Globally Important Agricultural Heritage Systems (GIAHS), ICID Register of World Heritage Structures etc.

There are no special archives on the protection of water heritage, but many management units of water projects have built archives, especially some major water projects. Most of the archives related to construction history have been collected and preserved systematically and completely. For example, most of the basin committees such as Huaihe, Yangtze, Pearl Rivers and Taihu Lake have archives. Among them, the existing archives of the Yangtze River Water Conservancy Commission contain as many as 1.4 million volumes (pieces). These heritage archives are not only centralised and systematically collected and preserved, but they also play an important role in modern water construction. In the future, the archives will continue to provide a historical basis for the compilation of governance planning and the formulation of general strategies for large rivers or river basins.

The archaeological achievements on water heritage are very rich, covering almost all typical types of water projects or facilities in typical historical periods, such as urban water supply and drainage systems, irrigation and drainage engineering, water transportation engineering, flood control engineering, etc. Most of the unearthed cultural relics are displayed in the corresponding museums. The archaeological excavation process and the brief introduction of its achievements are mostly published in *Archaeology*, *Cultural Relics* and *Archaeology Newspaper* and other journals. Some archaeological reports have also been published.

4. Historic and technical knowledge of water heritage

4.1. Historical evolution of the relationship between man and water

Human beings appeared very early in the tropic and subtropics regions of China. According to archaeological excavation, the discovery of the Yuanmou Ape Man fossil in Yunnan Province about 1.7 million years ago is the oldest known Homo erectus in China. About 7,000 years ago, the Hemudu cultural site in Yuyao, Zhejiang Province, excavated the oldest remains of cultivated rice and the earliest well in China. This shows that as early as the early Neolithic age, the ancestors of these areas have begun to enter the agricultural settlement life, and use simple tools to excavate ditches in low-lying areas for irrigation and drainage, thus the original irrigation and drainage engineering technology emerged. With the development of agriculture, the relationship between humans and water became closer.

In the historical period, the development of water conservancy in tropical and subtropical regions of China was closely related to the development of Chinese water conservancy history and Chinese history. Its development process can be divided into the following four stages.

The first stage was the development before the Qin Dynasty (221 BC to 206 BC). During this period, flood control engineering, irrigation and drainage engineering, water transport engineering, etc. began to develop further from the original state, and made some progress. Dujiang Weir, built by the state of Qin and now included in the World Heritage List, is an example of large-scale canal system projects. It irrigated Chengdu Plain with Minjiang River water, making Chengdu Plain a land of abundance, which greatly enhanced the economic strength of Qin State, so that the State of Qin was able to defeat the vassal states and finally unify China. The concept of taking advantage of the situation and adjusting measures to local conditions summed up by the local people during the construction of Dujiang Weir, and the ecological components they created, such as bamboo cages and wood tripod dam (Macha) are still of reference significance. When the people of Chu were in charge of the construction of Shaobei Weir they created an irrigation project that used water conveyance channels to connect the big and small ponds. Along the Grand Canal (included in the World Heritage List), its earliest excavated and still navigable sections are concentrated in this area. The completion of Lingqu Canal connected the Yangtze River and the Pearl River Basin.

The second stage was from the end of the Eastern Han Dynasty to the establishment of the Sui regime (220–581 AD). During this period, the water conservancy construction of the Yangtze River and the Huaihe River Basin were greatly developed. In the northern Yellow River Basin, there were frequent wars, frequent regime changes, and great damage to agriculture. However, the south of the Yangtze River was relatively stable and rich in water resources, so a large number of people migrated from the north to the south and brought various advanced technologies to the places where they migrated. With the growth of population, the demand for food was increasing, and the local rulers, out of the need for stable development, also attached great importance to the development of agriculture and the construction of water projects. As a result, more and more water projects were built in the south, and the technology of water projects was improved. In order to protect the growing population and their property, building of the Jingjiang Levee and the dikes of other tributaries of the Yangtze River began.

The third stage was in the Sui, Tang and Song Dynasties (581–1279 AD). During this period, water conservancy in this region was continuously developed. Polder fields were formed in the Taihu Plain, and the original engineering technology for the development of water and soil resources in low-lying areas was mastered. The middle and lower reaches of the Yangtze River and the Pearl River Delta were widely developed, and a lot of technical experience was accumulated. Construction of large flood control dikes began in the lower reaches of the Pearl River.

The fourth stage was in the Yuan, Ming and Qing Dynasties (1271–1911 AD). During this period, China's water conservancy began to develop towards the southeast coast and the Pearl River Basin. With the rapid growth of population in the southern provinces, the contradiction between more people and less land was becoming more and more serious. Therefore, significant reclamation of land began to appear in this area. At that time, the reclamation was mainly concentrated in the areas along the middle and lower reaches of the Yangtze River, so the area of polder fields in these areas increased rapidly. In order to ensure the safety of the very rich southeast coastal areas, the seawall was quickly built, the earth embankment was transformed into a stone embankment, and the layout and structure of the seawall were improved continuously, so that the seawall engineering technology was greatly improved. With the rapid extension of the coastal shoals, large-scale reclamation of the shoals began; this promoted continuous development of the technology for storing fresh water and blocking the sea water engineering system. The Grand Canal, which connects the economic and the political centres, were fully connected, systematic planning and comprehensive management were carried out in the area where the Grand Canal meets the Yellow River and the Huaihe River. In this period, the south of the Yangtze River, the eastern coastal areas and the Pearl River Basin were gradually developed, and the prosperity of water conservancy development in Jiangsu and Zhejiang was unprecedented in the previous generation. Since then, China's economic centre has been in the south.

In a word, there are a large number of traditional water projects in the area. After hundreds or even thousands of years of operation, many of them are still working, including Dujiang Weir, Lingqu Canal, Zhejiang seawall, etc. In addition, there are many traditional water conservancy engineering technologies, such as the ancient diversion facilities at headworks, bamboo cage components and polder technology, which are worth protecting and inheriting.

4.2. State of current research

Every year, the administrative department of cultural relics does a lot of excavation work and has found many ancient water conservation engineering systems, including irrigation, flood control, shipping and other engineering types, as well as urban water systems, such as the Liangzhu site in Zhejiang Province, Fushou ditch in Ganzhou, Jiangxi Province, etc.

In recent years, the management departments of cultural relics and cultural resources have attached great importance to the study of water history and water heritage. The main research involves the collation and publication of water conservancy documents. The most systematic data collection of the water conservancy history of China was *the Guide of water control (Xingshui Jinjian)*. In this series, the source and change of the river system, construction and evolution of their engineering, management of their engineering and other contents of the Yellow River, the Yangtze River, the Huaihe River, the canal and the Yongding River were extracted from hundreds of ancient documents. There were 10 million words, and the data sequence was more than 2,000 years. In addition, China is also reorganising most of the ancient water conservancy documents and publishing them together. This is a very meaningful and huge cultural project. The second is the research on traditional water projects and technologies, mainly focusing on irrigation, flood control, canal, seawall and other typical era and regional traditional water projects and their technical achievements. The third is the study of water history, including the studies of water history of a river basin or region, of water environment and water resources evolution, of flood and drought disaster history, of water conservancy social history, etc. The above research covers a wide range of contents and produces fruitful results, which are scattered in relevant books of major libraries and management units.

In recent years, both the cultural relics department and the water conservancy department have attached great importance to the protection of water heritage. The water conservancy department has twice issued documents to investigate water heritage throughout the country and achieved certain results. The protection of water heritage has been included as a key task in the water cultural development plan. The evaluation standard of the water conservancy heritage project has been compiled, and this provides a scientific basis for the classification protection in the future. At the same time, cultural heritage protection is an important item in many water projects.

5. Threats to water heritage

At present, most of the water heritage in China has been well protected and effectively managed.

However, most of the water heritages are located in open spaces, especially some still in use, so they are first damaged by various natural disasters, such as floods, mudslides, landslides and earthquakes.

Secondly, due to the diversity of their types, the numerous disciplines and fields involved, and different usage conditions, many technologies for their protection remain to be further studied. Thirdly, for the water heritage still in use, whether it will face the threat of damage depends on whether we can grasp the relationship between scientific protection and appropriate utilisation.

Even so, in recent years, with the high attention of relevant management units to heritage protection, the protection of water heritage is gradually integrated into various construction projects, and through various forms of publicity work, the public's awareness of the value and protection significance of water heritage is further improved, so that most traditional engineering systems are well protected and managed.

6. Legal protection in force

The legal system of water heritage protection and management mainly includes the following aspects:

1. **The legal system at the national level.** The protection and management of water heritage is mainly carried out in accordance with the *Cultural Relics Protection Law of the People's Republic of China.* The river courses and water projects that are still in use are protected by current laws such as t*he Water Law of the People's Republic of China, the Flood Control Law of the People's Republic of China*, and the *Regulations of the People's Republic of China on the administration of river management*.

2. **The local level or special legal system**. At present, many local governments have formulated local regulations or measures for the protection of cultural relics. Most of these laws and regulations are formulated according to the basic principles and requirements of the law on the protection of cultural relics and the basic situation of the protection and management of cultural relics. There are also special regulations on the protection of some specific water heritages, such as *the Grand Canal Protection Regulations*.

3. **Industry protection norms.** *Principles for the Conservation of Heritage sites in China*, issued by ICOMOS China, is the highest industry rule and main standard for the protection of cultural relics in China. It defines the basic procedures and principles of cultural relics' protection, standardises the practical work of cultural relics' protection in China, and has been widely publicised, popularised and used.

7. Conservation and management of water heritages

Most of the living water heritage is under the jurisdiction of water resources and transportation departments, while a small number of living water heritage and most engineering sites belong to water resources, cultural heritage administration, housing and urban-rural development, culture and tourism and other departments. Although world cultural heritages such as Dujiang Weir, Cultural Landscape of Honghe Hani Rice Terraces, West Lake Cultural Landscape of Hangzhou are managed by different departments, no matter which department is in charge, they all follow the requirements of cultural relics' protection.

The living heritage, such as the Grand Canal, has a huge system, interwoven with ancient and new projects, projects in use and ruins. The relationship between the protection and utilisation of cultural heritage is complex. It involves many departments such as cultural heritage administration, water resources, transport, ecology and environment, housing and urban-rural development, spanning 35 cities in 8 provinces. In major planning or practice, coordination is generally established at the national level which coordinates flood control, water supply, navigation, ecological and other functions of the Grand Canal and related water systems, so that it can continue to play a water conservancy function on the basis of scientific protection, and provide education, leisure and tourism functions to further promote the local economic and social development and the improvement of the living environment, as well as promote sustainable development of the local area.

In China, there is consensus to regard the traditional water project as a heritage for scientific protection and appropriate utilisation, and planned actions are being undertaken. However, the protection of water heritage is a new topic, which may face the following two difficulties:

First, the construction of a water project is a giant complex system, which is not only related to engineering technology, but also closely related to economic, social, environmental, ecological, landscape improvement and other factors. In the protection of water heritage, these factors should be fully considered, and knowledge in relevant fields and management objectives of different departments should also be understood. At the same time, water heritage not only has the characteristics of heritage in a general sense, and the need to be protected according to the relevant requirements, it is also a living project, which still has benefits, therefore we need to give full consideration to the various benefits. Thus, it is very difficult to find the balance between protection and utilisation in the protection of water heritage.

In fact, some cases in recent years show that many engineering designers or decision-makers have realised that the reconstruction and expansion of traditional projects is not only a technical problem, but decisions also need to be based on various influencing factors. In this process, the protection of a water heritage site is relatively simple. In many cases, bypass the heritage site or build a new project next to it. However, the problem of linear channel, especially the large-scale river channel, is relatively complex, nevertheless people are still actively exploring the idea. For example, in the process of renovating and upgrading the Grand Canal, Huai'an, Yangzhou, Wuxi and other cities along the line all choose to excavate new canals outside the city, while the old canals crossing the urban area are retained and upgraded as landscape rivers. This not only brings great economic benefits, but also has social and ecological benefits.

The second is that the natural conditions of this region are very different, the spatial and temporal distribution of water resources is uneven, and the social and economic development needs of each sub-region are different, which gives the water heritage the characteristics of rich types. Their richness is not only reflected in heritage types, but also in heritage engineering technology and building materials. For example, traditional dikes used to be dominated by soil, brick and stone structures in the historical period, and concrete was used in modern times; ship locks experienced technological evolution such as weir, single gate and compound gate. Its richness also reflects the existing state of heritage, some are single projects, some are engineering systems, some are combined heritage, and even the linear heritage formed with the core of a flowing river. Its richness is also reflected in its continuous use, regular maintenance and reconstruction of hydraulic structures. In this process, the technical traces of different historical periods are superimposed and continue to this day. These characteristics undoubtedly increase the technical difficulty of their protection, and even some of them are new topics that need further study. These characteristics undoubtedly put forward higher requirements for their protection technology, and even need to set up new topics to meet the new requirements.

The protection, inheritance and development project of the Grand Canal is a good case for active exploration. Founded in 486 BC, it has a history of 2,500 years and a total length of more than 2,000 kilometres. It spans 8 provinces and 35 cities in the eastern developed areas of China and connects the five major water systems of the Haihe River, Yellow River, Huaihe River, Yangtze River and Qiantang River. Moreover, along the Grand Canal, ancient projects and new projects coexist at the same time, living projects and abandoned sites interweave with each other, thus forming a huge system, part of which has been inscribed on the World Heritage List. In the preparation of its protection and utilisation planning, a coordination mechanism had been established at the national level, with the participation of relevant departments such as cultural heritage administration, water resources, transportation, ecology and environment and local governments, to coordinate the heritage protection of the Grand Canal and its functions of flood control, water supply, shipping and ecology, as well as the improvement of the landscape and environment of the region, and the economic and social development of the region where the Grand Canal flows, development and so on.

In addition, in recent years, the Department of Water Resources began to integrate heritage protection tasks and cultural elements into the planning and design of water projects involving heritage, and put them into practice in the construction process, which not only protected many water heritages, but also produced good social, economic and environmental benefits. Their work mainly includes the following:

1. Through the management and protection of the heritage of water projects, especially those traditional projects that have hundreds or even thousands of years of history but still play a role, make them continue to play the functions of irrigation, flood control and drainage, shipping, water delivery, water supply and so on. For example, Dujiang Weir still irrigates the vast Chengdu Plain, Mulan Weir still plays a role in storing fresh water and retaining sea water, and the seawalls along the Qiantang River still protect the life and property of people in the southeast coastal areas.

   Many traditional water projects are the historical and cultural accumulation of the region, which embodies the relationship between water conservancy and the economy, society, environment, ecology and culture of the region in the historical period. They are important elements of regional history and culture. Relying on these heritages, many regions had made appropriate use and innovative inheritance and development and built a significant regional water landscape according to local conditions. For example, through appropriate utilisation, water project heritages such as the seawall along the Qiantang River and Hani Terrace in Yunnan have become famous tourist attractions at home and abroad. As of 2021, China had 902 National Water Parks, many of which were located in tropical and subtropical regions.

2. Relying on heritage with better resource conditions, the exhibition of heritage itself and its history has been carried out, for example, Dujiang Weir and Lingqu Canal; some water conservancy museums or exhibition halls, such as Chongqing Baiheliang Underwater Museum, have been built to show the development process, achievements and influence of water conservancy in the basin or region to the public. They advocate the concept of saving water and caring for water resources, so as to effectively play the social functions of education, science popularisation, memorial and research of water heritage. Some national hydrological education bases have also been established by relying on water heritage. As of 2021 more than 61 units have joined the China Water Conservancy Museum Alliance, and 71 have been as the National Water Education Base. Also in 2021, China's first batch of National Water Heritage identification was launched.

Through scientific protection and proper utilisation, the living water heritage can not only be preserved and operated for a long time but can also promote the sustainable development of the local economy and society and the improvement of environment.

8. Conclusion

China's tropical and subtropical regions cover a vast territory, complex in geographical conditions, widely different in hydrometeorology, inhabited by many nationalities with different customs. The demand for economic and social development varies from region to region. People here have been building and developing different types of water projects from a very early age according to the natural geography and hydrological and water resource conditions. This gave the water heritage in this region characteristics of large quantity, rich types and wide distribution. Among them, in the southeast coastal areas, there were many irrigation projects for storing fresh water and blocking the sea water; in the lake area of the Yangtze River Basin, the polder engineering system was mainly built; the Huaihe and Hanjiang river basins are located at the North-South junction of climate, where there were many irrigation projects combining canals and ponds (like a long vine with several melons); in the hilly and mountainous area of South China, small ponds were the main irrigation works. This shows that the water heritage in the region also has a significant epochal and regional character, some of which represent the advanced level of water conservancy engineering technology in China and even in the world at that time. Many projects are still making use of their benefits.

The water project system is a giant complex system, involving various fields, departments and regions. It not only has the characteristics of heritage in a general sense, but some are still in use, even the indispensable backbone projects in its area. On the one hand, as heritage, the management of them should be carried out in accordance with the requirements of cultural relics' protection; on the other hand, as a living heritage, we should take full account of its proper use on the basis of protection. This mainly includes two aspects: first, on the basis of protection, their traditional water conservancy functions such as irrigation, flood control, shipping and power generation should be continued; meanwhile, their social functions should be expanded. For example, depending on the water heritage, the project itself can be displayed, and a museum or exhibition hall related to water can be built to provide the public with a place to understand the process of water resource protection and development and utilisation, and a place to understand the importance of water conservation and protection. Second, depending on the water heritage and the water body where it is, combined with various kinds of water projects such as urban and rural construction projects, scenic spots, leisure projects, tourism projects, etc. can be built, which can not only enhance the cultural connotation and taste of construction projects, improve the living environment of nearby residents, but also promote the sustainable development of the local economy and society.

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05. China: Southern China

Regional overview: Cultural heritages of water management in the southern coast of China

By Zhou Bo, Associate Professor, China Institute of Water Resources and Hydropower Research

1. General characteristics

The southern coast of China includes Guangdong Province, Guangxi Zhuang Autonomous Region, Hainan Province, Macao and Hong Kong Special Administrative Region. At present, there are many existing water heritages in Guangdong and Guangxi, and there are also many excavation and research results. Hainan, Macao and Hong Kong have relatively few water heritages. In this section, we mainly introduce the important water heritage of Guangdong and Guangxi.

The Pearl River Basin is composite and belongs to Guangdong Province and Guangxi Zhuang Autonomous Region. The Pearl River is the largest river in South China. It is composed of four water systems: Xijiang River, Beijiang River, Dongjiang River and other rivers flowing into the Pearl River Delta. Among them, the Xijiang River is the longest and is often called the trunk of the Pearl River. There are many rivers in the basin, including 8 rivers with a catchment area of more than 10,000 km² and 49 rivers with a catchment area of more than 1,000 km².

The Pearl River Basin is located in the subtropical zone. The Tropic of Cancer runs through the central part of the basin. The climate is mild and rainy, and the annual average temperature is between 14℃ and 22℃. The Pearl River Basin is rich in water resources, and precipitation is the main source. The average annual rainfall is 1200–2200 mm. The distribution of rainfall gradually decreases from east to west, and the annual distribution is uneven. The regional distribution difference and interannual variation of rainfall are large. Guangxi and Guangdong, located in the middle and lower reaches of the Pearl River Basin, especially the areas near the South China Sea and the Delta, have abundant rainfall and large run-off.

The Pearl River Basin is vast in area and has a complex geological structure. The topography of the basin is high in the northwest and low in the southeast. The upper reaches of the Pearl River are located in the valley areas of Yunnan Guizhou Plateau and Guizhou Guangxi high mountains, with an altitude of more than 1,000 metres; the middle reaches are mixed with mountains and hills; the lower reaches connect with the alluvial plain of the Pearl River Delta.

2. Known sites and important sites for the cultural heritage of water

The water heritage in Guangdong and Guangxi mainly includes two parts: the living sites still in use and the cultural landscape related to water.

2.1. Living sites

At present, the living water heritage still in use mainly includes Sangyuanwei in Guangdong and Lingqu and Xiangsidai in Guangxi.

2.1.1. Sangyuanwei

Sangyuanwei is a famous ancient large-dike-surrounded field in the Pearl River Delta. It is located in the lower reaches of Xijiang River, one of the main streams of the Pearl River in Nanhai and Shunde County, Guangdong Province. It is surrounded by Beijiang and Xijiang dikes, named after a large number of mulberry gardens. It was first built in the reign of Emperor Huizong of the Northern Song Dynasty (1101–1125). At first, there were only the East and West dikes. Four years later, Jizan Hengji dike was built. Then, Shatou Zhongtang, Longjiang Hepeng, Sangyuanwei and Ganzhu Jifen dike-surrounded fields were built respectively. During the Ming and Qing Dynasties, 14 small fences, including Baoan, were built successively. In the early period of the Republic of China, the dike of Longjiang River section in Shunde District was raised and became field areas surrounded by dikes. In 1924, Sangyuanwei became a relatively complete dike-surrounded field area after the construction of three sluices, namely, Ge, Longjiang and Shihankou. The completion of Sangyuanwei dike-surrounded field has changed the traditional farming production mode and played an important historical role in the economic and social development of the Pearl River Delta region. It is an important foundation and cultural symbol for the economic and social development of Lingnan water town, and also the concentrated embodiment of 'Guangdong people are good at water'.

Fig. 1: Photos of Sangyuanwei in Nanhai County in 2019. © *Liu Lizhi.*

Sangyuanwei has a long history and extends over two counties. Local people have accumulated a set of effective management methods in the construction process. A general administration would be set up in the whole enclosed area to take charge of the whole enclosure affairs, and special personnel would be assigned to manage each section of the dike. The management regulations were mainly aimed at dike repair and maintenance, which were revised three times from Jiaqing to Daoguang in Qing Dynasty. The dikes are related to the safety of the whole area, and the 14 fortresses in it are responsible for the maintenance of the dikes by apportioning food funds; each fortress was responsible for the management and maintenance of secondary levees, and management regulations were formulated. In the documents written in the Qing Dynasty, the history and engineering management of the mulberry garden are recorded in detail.

At present, Sangyuanwei has a total length of 68.85 kilometres and an area of 133.75 km². It still irrigates 4214 hectares of farmland, playing a variety of roles such as irrigation, flood control and water transportation. It is not only the crystallisation of the wisdom of the people in the Pearl River Delta, but also a precious cultural heritage that modern people should protect.

2.1.2. Lingqu Canal

Lingqu, also known as Douhe or Xing'an canal, is an ancient canal connecting the Yangtze River system and the Pearl River System in China. It is located in Xing'an County of Guangxi Zhuang Autonomous Region. After Qin unified the six kingdoms, in order to use troops to Lingnan (Guangxi and Guangdong Province), in the 28th year of the first emperor of Qin Dynasty (219 BC), he sent the imperial censor named Lu to excavate Lingqu Canal to transport grain, which connected the Xiangjiang River of the Yangtze River system and the Lijiang River of the Pearl River system, which was the main traffic trunk line between Lingnan and Central Plains.

Fig. 2a: Big and Small Tianping in 2002. © *Wang Lili, FOTOE.*

Fig. 2b: Big and Small Tianping when passing water, in 2005. © *Qin Jiangying, FOTOE.*

Lingqu Canal is composed of three parts: the head works, the South Channel and the North Channel. The head works of the canal are to block the upstream section of Xiangjiang River (called Haiyang River) with a barrage, raise the water level, divide the water into the south channel and the north channel, respectively communicate with the downstream of Lijiang River and Xiangjiang River, so as to make navigation possible. The barrage, also known as the Big Tianping and the Small Tianping, raises the water level in normal times and makes it flow into the North and South Channels; in flood season, the surplus water overflew from the top of the Tianping into the old Xiangjiang River downstream. The South Channel starts from the intake gate, i.e., Nandou, and ends at the Darongjiang River in the upper reaches of Lijiang River, with a total length of 33km. It is divided into artificial, semi-artificial and natural reaches. The man-made river reach is from Nandou, the mountains are cut, the river is opened, the dike is built, and the watershed is crossed until the easternmost tributary of Lijiang River. The semi-artificial river reaches from the downstream of Shi'anshui River mouth to the confluence with Qingshui River, which was originally Shi'anshui river channel, and was artificially widened to navigation standard on the natural river; From Qingshui River mouth to Lijiang River, it is a natural river course with shallow water and many reefs. It has been artificially regulated many times in history. The function of South Canal is to make navigation between Xiangjiang River and Lijiang River possible. The North Canal starts from the intake gate, i.e., Beidou. Another artificial channel is excavated along the right bank of the original channel of Xiangjiang River, with a length of 3.5 km. Its function is to realise the navigation from the reservoir to the lower reaches of Xiangjiang River, and to ensure the reasonable diversion of water at the head of the canal. There are dozens of bends on the canal and many flood diversion and water-saving structures have been built to ensure the safety of the channel and navigation depth.

Lingqu Canal, as the main traffic line between Guangdong Province, Guangxi Province and Central Plains, was maintained until the completion of the Beijing–Guangzhou railway and the Hunan–Guangxi railway. After 1949, Lingqu Canal became a water conservancy project with irrigation as its main function and urban water supply, industrial water supply, scenic tourism and other comprehensive benefits. In 2018, Lingqu Canal was included in the World Irrigation Project Heritage List.

Fig. 3: Nandou sluice gate, in 2015.

2.1.3. Xiangsidai Weir

Xiangsidai Weir, also known as the ancient Guilin Liujiang canal, is a branch dam on the artificial canal connecting Liujiang River and Lijiang River in ancient times. It is located in the south of Guilin City in Guangxi Zhuang Autonomous Region. It connects Liangfeng River, a tributary of Lijiang River, and Xiangsi River, a secondary tributary of Liujiang River. It directly connects Guilin with the northwest of Guangxi and the southeast of Guizhou Province, and it is thus possible to avoid the long journey back to Liujiang River from Lijiang River to Wuzhou. The project was built in 692, the first year of Changshou in the Tang Dynasty. From the Tang Dynasty to the Ming Dynasty, the canal was mostly built. In the ninth year of Emperor Yongzheng of Qing Dynasty (1731), it was overhauled, and 22 Doumen (sluice gate) and some flood discharge structures were built. The overall planning and building type of the project are similar to that of Lingqu. Therefore, the two canals are called the North-South two Dou rivers, or Guilin's East-West two Dou rivers.

The construction project of Guilin-Liuzhou canal includes a water diversion pond, sluice gate, east-west channel, Doumen, culvert and bridge, etc. The water diversion pond is in the middle of the canal. There is no obvious watershed. The groundwater has been flowing out from the low mountain rock cave for a long time, but the water volume is not large. It is the original water source of the canal and plays the role of water storage and diversion. In the south of the pond, there is a discharge dam. Its function is the same as that of the Big and Small Tianping of Lingqu Canal, which can hold water and discharge flood water. There is a sluice gate at the interface between the East and West Channels and the diversion pond, which is opened and closed manually to regulate the water consumption of the channel. Doumen were built in the East and West Channels to store water and sail. From the water diversion pond, it is called Dongdou in the East, and the water flows eastward into Liangfeng River; in the west, it is called Xidou, and the water flows westward into Xiangsi River. The gradient of the canal is gentle. When the Liangfeng River rises, the river water can be discharged into the Xiangsi River through the canal; when the water of the Xiangsi River rises, it can discharge into the Liangfeng River through the canal, which has the function of balancing the water quantity and discharging the flood water.

Xiangsidai Weir connects the Yangtze River system with the Pearl River system and has been the main traffic artery from the Central Plains to Lingnan and Lingxi (Yunnan and Guizhou Province) since ancient times. Guilin-Liuzhou canal can be used for navigation, drainage and irrigation. It plays an important role in economic and cultural exchanges, agricultural development and fishery production in the Lingnan and Lingxi areas. It was navigable in the 1940s. After 1949, it was transformed into a comprehensive utilisation water conservancy project mainly for drainage.

2.2. Cultural landscapes related to water

This type of heritage mainly includes Longji Terrace in Guangxi and Mulberry-Dike Fish Pond in Guangdong Province.

2.2.1. Longji Terrace

Longji Terrace refers to the terrace developed on Longji Mountain, which is called Longsheng terrace in the broad sense and Longji terrace in the narrow sense. It is located in the Longji Mountains, Pingan village, Longji Town, Longsheng Autonomous County, Guangxi, 22 km from Longsheng County. It is 80 km from Guilin City. Longsheng is located in the Nanling Mountains. As early as 6,000 to 12,000 years ago, the original cultivation of Japonica rice began, thus it is one of the first birthplaces of artificially cultivated rice in the world. In the Qin and Han Dynasties, terraced farming was started in Longsheng. In the Tang and Song Dynasties, Longsheng terraces were developed on a large scale, and basically reached the existing scale in the Ming and Qing Dynasties. Longsheng terrace has a history of at least 2,300 years and can be called the hometown of terraces.

Longji terraces, in general, refer to the terraces of Ping'an Zhuang Nationality in Longji, which are also the earlier developed terraces. They are distributed between 300 metres and 1,100 metres above sea level, with a maximum slope of 50 degrees. According to the statistics of relevant departments in Longsheng County, there are about 3,900 hectares of terraces in Longsheng County, including 353 hectares in Longji terrace agricultural system, accounting for about 10 per cent of the total terraced fields in the county. Longji is named because the mountain is like the back of a dragon. On the left side of the mountain is SangJiang River, and on the right are the terraces dug by ancestors of the Zhuang and Yao people, namely Longji terrace. At present, Longji terrace mainly includes three parts: Pingan Zhuang village terrace, Longji ancient Zhuang village terrace and Jinkeng Hongyao terrace, which is the core protection area of agricultural cultural heritage. In 2013, Longji terrace was included in the list of Important Agricultural Cultural Heritage in China. In 2018, Rice Terraces in Southern China (including Longji Terraces in Longsheng County, Guangxi Province, United Terraces in Youxi County, Fujian Province, Kejia Terraces in Chongyi County, Jiangxi Province, and Ziquejie Terraces in Xinhua County, Hunan Province) were included in the list of Important Global Agricultural Cultural Heritage.

2.3.2. Mulberry-Dike Fishpond

Mulberry-Dike fishpond is an efficient artificial ecosystem created for the full use of land in the Pearl River Delta region of China. The fishpond is dug deep, its dike is raised, mulberry is planted in the pond dike, and fish are cultured in the pond. It was first created by the people in Xiqiao Mountain and Pearl River Delta in Guangdong Province in the Ming Dynasty. The height of the dike increased in the early Qing Dynasty and was finalised in the late Qing Dynasty. By the 1920s, the Pearl River Delta was covered with Mulberry-Dike fishponds, with an area of 80,400 hectares, reaching the highest level in history. A simple explanation of the so-called Mulberry-dike fishpond is that mulberry is planted in the pond dike, fish are raised in the pond, silkworms are raised in mulberry leaves, and the fish eat the silkworm excrement. So, this combination of the silkworm excrement feeding the fish, the pond mud fertilising the mulberry, mulberry planting, silkworm rearing and fish culture, form a virtuous circle in which mulberry, silkworm, fish and mud are interdependent and mutually promoted. Its advantages lie in that it can avoid water logging, create an ideal ecological environment, and thus achieve good economic benefits and reduce environmental pollution. Its emergence and development are closely related to the geography, water conservancy, economy, science and technology, ecological conditions and their development of Xiqiao Mountain and the Pearl River Delta.

Mulberry-Dike fishpond not only promoted the development of mulberry planting, silkworm rearing and fish culture, but also promoted the silk reeling and other processing industries, and thus developed into a complete and scientific artificial ecosystem. This intensive, specialised and diversified agricultural management is the first way to coordinate the development of economy, environment, resources and society in China's history, realising the unity of ecological benefits, economic benefits and social benefits. This method is of universal significance to the Pearl River Delta and all coastal areas, and also marks the fact that the Pearl River civilisation has entered the era of conscious scientific farming.

Fig. 4: Sangji fishing pond in Jun'an Town, Shunde County, Guangdong Province, in 2005. © *Ange, FOTO.*

Since the twenty-first century, the Mulberry-Dike fishpond, an ancient ecological agriculture model, has been extended to all parts of Southeast Asia.

3. Existing documentation

At present, there is no specific list of water heritage in the coastal areas of southern China. The recent surveying and mapping, database data and photos of Lingqu, Sangyuanwei and Longji terraces can be obtained from the materials of various heritages declared by the local government in recent years. Archives, written information, and early maps and plans of water heritage in southern China can be obtained from the following five types of materials:

Local records and water records. For example, there are local records about Lingqu Canal, such as *Xingan County Annals*, *Water Conservancy Records of Xing'an County*, and *Longsheng County Annals* about Longji Terraces. Local records are important sources of historical and map information about water heritage.

Ancient special local records related to water heritage. At present, there are three ancient books about Sangyuanwei dike-surrounded field: *General Records of Sangyuanwei*, *Continuation of Sangyuanwei Records* and *Re-compilation of Sangyuanwei Records*. *General Records of Sangyuanwei* is a collection of many local records and official water conservancy documents over more than 100 years of the Qing Dynasty.

Genealogy and other folk documents. Some water heritages, such as Sangyuanwei dike-surrounded field, Lingqu Canal and Mulberry-dike fishpond, are often located in areas where clan culture is well developed and almost every village had its own genealogy. There are some unofficial materials recording water heritage.

Personal monographs or Anthologies on these water heritage sites. For example, Zheng Liandi's *A Brief History of Lingqu Project* and *Papers of the Symposium on the History of Water Conservancy in Sangyuanwei and the Pearl River Delta*, etc.

Comprehensive monograph on water conservancy. For example, the introduction of water heritage in the coastal areas of southern China in comprehensive water conservancy monographs, such as *The Draft of Chinese Water Conservancy History*, T*he Brief History of Pearl River Water Conservancy*, and *The History of China's Irrigation and Flood Control.*

4. State of historic and technical knowledge concerning water heritage in this region

There is abundant rainfall in the Pearl River Basin, but the seasonal distribution of rainfall and crop growth needs are still different. At the same time, there are a few plains and steep rivers in the basin, which lack lake regulation and storage in the middle and lower reaches. Therefore, the task of irrigation, flood control and waterlogging removal is also very urgent. Water conservancy in the Pearl River Basin started later than the Yellow River Basin and the Yangtze River Basin. Its development can be roughly divided into four stages: the initial development before the Song Dynasty (960–1279); the rise of the Song and Yuan Dynasties (1271–1368); the development of the Ming (1368–1644) and Qing Dynasties (1644–1912); and the introduction of modern western technology. The main types of farmland and water conservancy projects include the dike-surrounded field of the Pearl River Delta, that is, the coastal farmland water conservancy system similar to the dike-surrounded fields in the south of the Yangtze River and the dike-surrounded fields of Dongting Lake; there are water diversion projects from rivers; and water storage projects in mountain ponds. Among them, the pond has been recorded in the Han and Tang Dynasties, and Longfubei Pond in Lianzhou is said to have been built in the Eastern Han Dynasty. Since then, the dike-surrounded field in the Pearl River Delta is the most concentrated, with significant project scale and social benefits.

Water conservancy in Guangzhou was developed earlier in the Pearl River Basin. In the Tang Dynasty, there was Shibei Pond in the northeast of Zengcheng, and in the Song Dynasty, there was a pond named Tiantangshui in the west of Zengcheng. The construction of ponds increased significantly in the Ming and Qing Dynasties. According to incomplete statistics, at that time, there were 27 ponds in Zhaoqing Prefecture. Among them, there were 6 ponds with an irrigation area over 100 hectares and 5 ponds with irrigation area less than 100 hectares. In addition, 16 ponds had no specific irrigation area. The diversion canal system in Guangdong was recorded in the Song Dynasty at the latest. According to records, 1,120 hectares of farmland were irrigated with Xinfengjiang River water in Heyuan County at that time. In the northeast of Lechang County, Lingxi water, a tributary of Wushui River, irrigated more than 120 hectares of farmland.

In Guilin, Nanning, Liuzhou and other places in Guangxi, the origin of the pond engineering is also earlier. In the Tang Dynasty (618–907), the governor of Guizhou (707–709) built Lingbei Pond 6.2 miles northeast of Guizhou Prefecture. During the reign of Qiandaozhong and Chunxi in the Song Dynasty, it was repaired. It was abolished in the late Ming Dynasty. In the early years of Tanghe (806) of the Tang Dynasty, Wei Dan was appointed governor of Rongzhou. He built 598 ponds in the area of today's Jiangxi Province, and set up 24 garrisons; he also built some irrigation projects. During the reign of emperor Yuanyou in the Northern Song Dynasty (1049–1053), Tonggubei Pond was built 6.2 miles north of Nanning city. In the Jiajing period of the Ming Dynasty, it was maintained and irrigated the farmland of Su and Lu villages. According to records, there are 17 ponds in Guilin, of which the North and South Weirs irrigate more than 2,000 hectares.

5. Threats on water heritage and protective measures

At present, the threats to water heritage in the region are mainly based on the following points:

First, human behaviour and urban construction are the biggest threats to water heritage in the coastal areas of southern China. Due to the social and economic development and urban construction, some development for the purpose of economic development has an impact on the environment and landscape of water heritage, which threatens the authenticity of water heritage.

In view of the above situation, the most important solution is to formulate the corresponding protection plan, from the top-level design to prevent the destruction of water heritage by human behaviour and urban construction. In 2014, a series of management measures and plans, such as the measures for the protection of Lingqu Canal in Guangxi Zhuang Autonomous Region and the measures for the protection and management of Longji terraces in Longsheng Autonomous County of Guangxi Zhuang Autonomous Region, were formulated and promulgated successively. They standardised and restricted the construction activities, ecological environment and water conservancy facilities of the heritage area, and effectively strengthened the farming culture and terrace tourism resources of Longji Terrace. To a certain extent, these measures also promote the coordinated development of the economy and ecological environment.

The second main measure is to guide residents to participate in the protection of water heritage. For example, in order to maintain the traditional rice planting mode of Longji terrace and protect the terrace landscape, the local people's enthusiasm for rice planting was stimulated by providing subsidies. Each village and group also set up management and protection teams to maintain and manage the terrace water conservancy facilities. At the same time, the residents of Sangyuanwei were to participate in the protection work and combine the heritage protection with the activation of old blocks and rural renovation. Other threats to water heritage include: excessive or blind restoration of some heritage; failure to strictly follow the principles of original materials, original structure and original technology, resulting in damage of authenticity; some unknown water heritage is gradually destroyed due to lack of attention and maintenance; multi-management and imperfect management mechanism, etc.

6. Legal protection in force

According to *The Law of the People's Republic of China on the Protection of Cultural Relics*, the water heritage listed in the world heritage or cultural relics protection units at all levels has effective legal protection. In Guangxi Province, *The Regulations on the Protection of Cultural Relics in Guangxi Zhuang Autonomous Region* were formulated in 2013, and *The Measures for the Protection of Lingqu Canal in Guangxi Zhuang Autonomous Region* were formulated in 2014.

7. Conservation and management of water heritages

7.1 Protection of water heritage

At present, the protection of water heritage is quite satisfactory. For the water heritage listed in cultural protection units at all levels and various heritage lists, there are relatively perfect protection methods, management regulations and plans, which effectively protect the landscape, physical objects and main projects of water heritage.

7.2 Management of water heritage

The management of water heritage in this area belongs to different industry management systems, mainly including the water conservancy system, cultural relics system, tourism system, etc. In view of this multi-management situation, it is generally supervised by the local government, implemented by the beneficiaries of heritage economy, and jointly managed by local people. The other way is to set up an organisation similar to the heritage protection and management committee in the place where the water heritage belongs, which combines cultural relics, tourism, water conservancy, archaeology and other departments into a joint collaborative management organisation.

7.3 Sustainable development and current management of living heritage

At present, living heritage protection and management awareness is relatively strong, through effective protection measures and management mechanism adjustment, can promote the sustainable development of living heritage. However, the relevant protection, planning and management must be considered and demonstrated according to the practical needs of social and economic development, the comprehensive development of water conservancy functions, the requirements of comprehensive allocation of water resources, heritage protection and cultural display.

8. Conclusion

At present, water heritage in the coastal areas of southern China is gradually becoming better protected, the management system is gradually clear, and the water heritage in Hainan Province is also being gradually excavated. However, in addition to the famous heritage sites, other water heritages not listed are still lacking systematic investigation, protection and management. Some important water heritage may be ignored and destroyed in the construction of cities and towns. At the same time, we should also pay attention to the overall planning of heritage protection, utilisation and management, combined with the development of water conservancy, agriculture and tourism, ecological civilisation construction, rural revitalisation, to promote the sustainable utilisation of water heritage. We suggest that in the future, we should strengthen the systematic investigation of the water heritage in this area, and on this basis, put forward the protection measures of the heritage, formulate effective protection and management planning, and improve the management of the heritage, so as to promote the sustainable utilisation of some available water heritage and slow down the damage caused by tourism economy and urban construction.

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Case study: Water Heritage of Hani Rice Terraces, with a Special Focus on UNESCO World Heritage Property

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1. Introduction

1.1 General Climate Data and horological figures

Hani Rice Terraces are concentrated in four counties that belong to the Ailao Mountains: Yunnan, Honghe, Lvchun and Jinping Provinces, Honghe prefecture, Southwest China. However, the world heritage property is located in Yuanyang County with almost 55,000 hectares and altitudes of 700–1800 m, in a subtropical mountain monsoon climate – rain in the hot season. The annual temperature difference is big, but the daily temperature difference is small, the weather conditions vary with altitude. Moreover, the annual average rainfall is 1397.6 mm which makes Yuanyang wet and humid and with fog all year round. Precipitation accounts for 78 per cent of the annual amount with 3 to 7 days' heavy rains. From November to April, it is dry with long days and sunny weather. In the period between May and October, there is an abundant source of moisture because of the southwest monsoon.

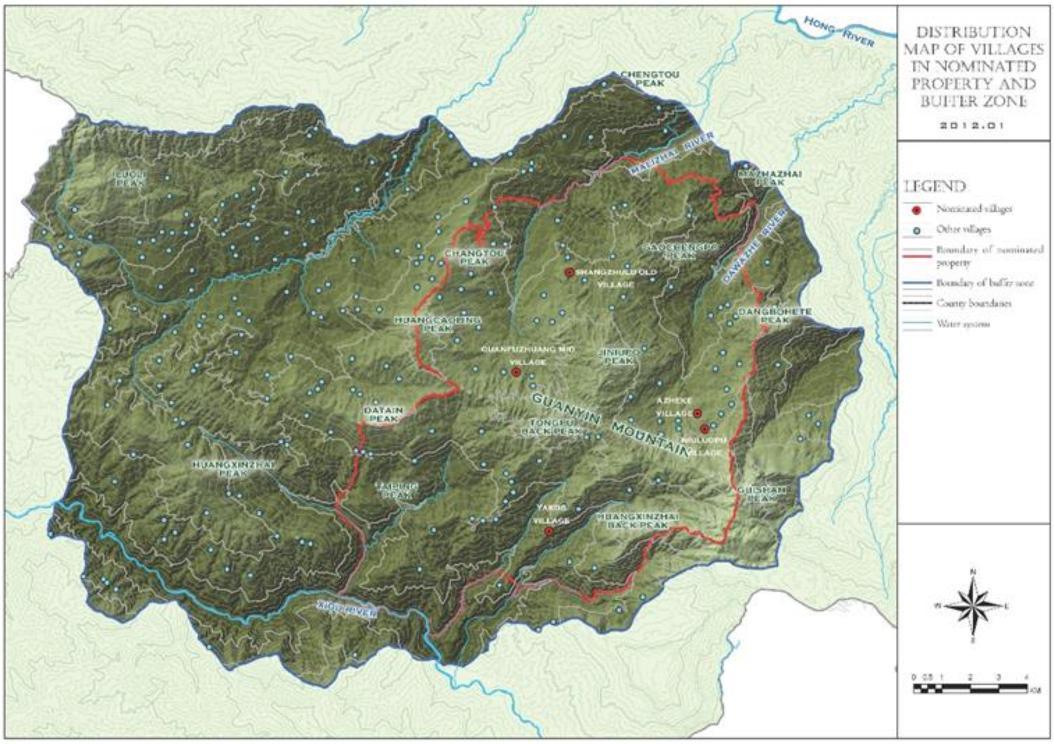

Fig. 1: Distribution map of villages in nominated property and buffer zone *(Nomination File, 2003).*

1.2 Characteristics of water heritage in Honghe Hani Rice Terraces

Honghe Hani Rice Terraces (HHRT) sites were inscribed on the UNESCO World Heritage List in 2013, under criteria (iii) and (v). They are also recognised as a cultural landscape.

In the Statement of Outstanding Universal Value (OUV) of the HHRT, four key attributes of cultural heritage are presented: 1) Ancient highly developed agricultural system of rice terraces ; 2) Special management system of agricultural society; 3) Culture-social system combined of Man and God ; 4) The unique landscape pattern of 'Forest-Village-Terrace-River'.

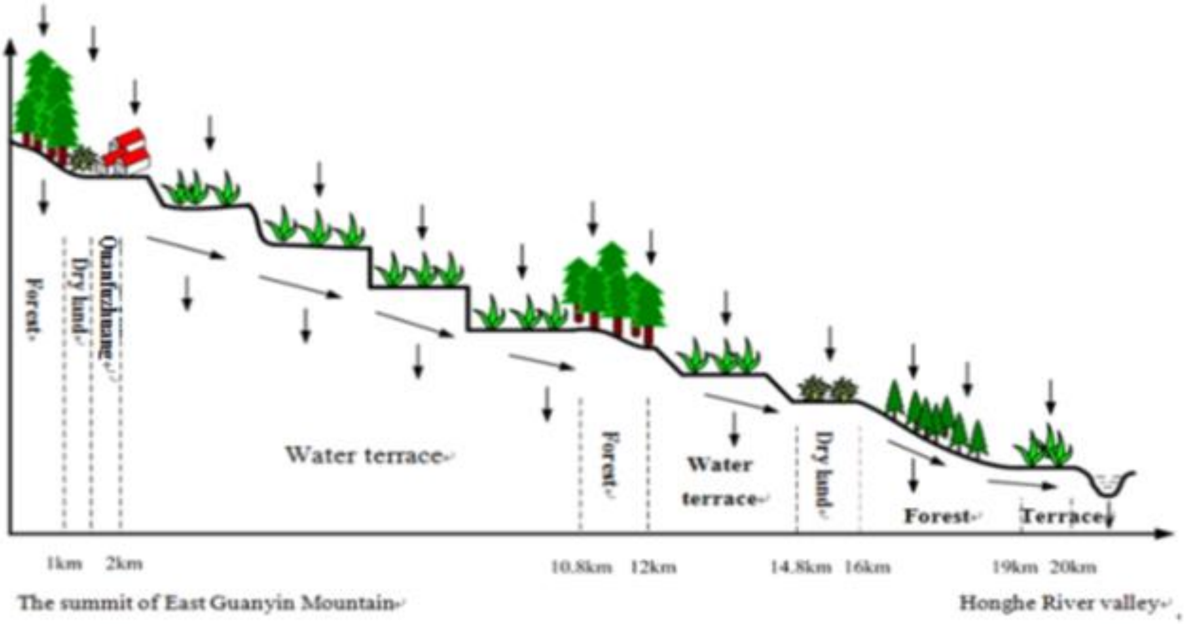

Fig. 2: The landscape pattern of 'Forest-Village-Terrace-River*. (Nomination File, 2003).*

Fig. 3: The landscape of Hani Rice Terraces. © *Li Yuxin.*

In Hani people's settlements and farming lands, especially in the property, water plays a key role in providing basic products. It is a necessary support to human well-being with food, forage, and bio-energy. As for ecological functions, hydrological flow and canals carry materials and energy from the top to the bottom of the mountains. In this process, transformation of elements and biodiversity are contributed to environmental development, maintaining water and soil, regulating local climate, and providing a clean living environment.

Fig. 4a-4b: Vertical flow of water among paddy fields. © *Li Yuxin.*

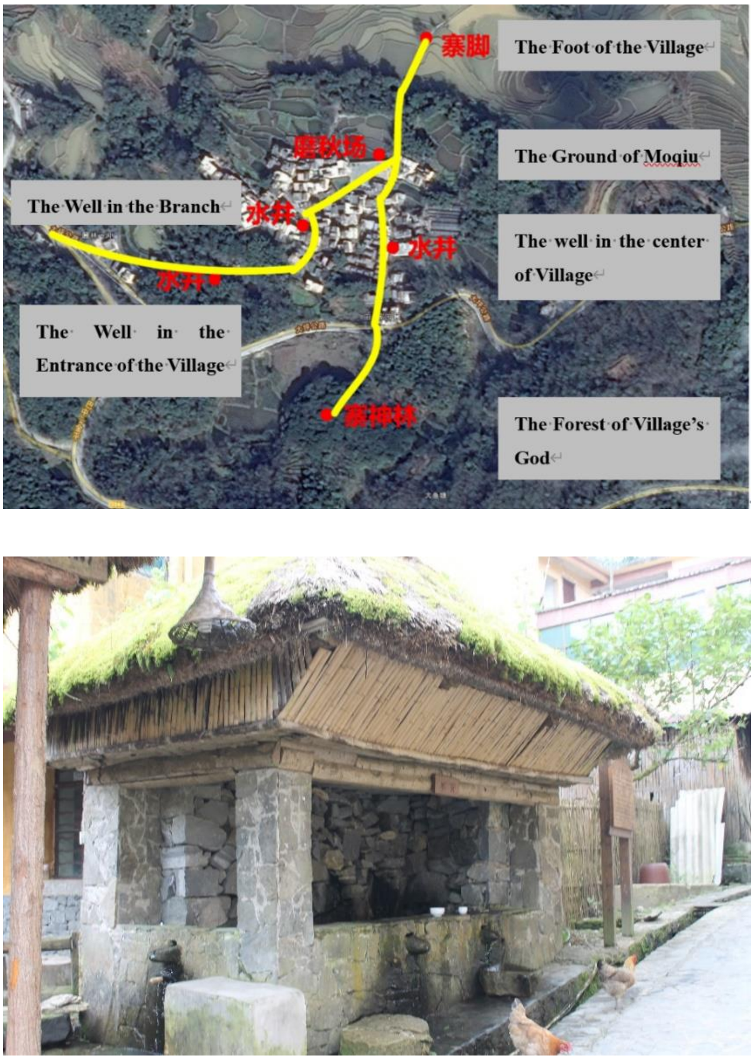

Fig. 5a-5b: Nodes of a village with water heritage in Dayutang Village. © *Li Yuxin.*

Water technology contains the wisdom and philosophy of shaping lands and distributing profits, to ensure equity under limited and quantitative resources within a village and among several villages in a sub-basin. Jiao (2008) states that sharing water resource is a virtue of the Hani people. Because every paddy field can get enough water no matter how big it is to maintain the terraces sustainable, and the principles are transparent to the public and very strict in Hani society. Thus, the principles of managing and protecting water could be regarded as local rules and regulations to conserve the terraces and villages to ensure that every paddy field can get a reasonable volume of water in the dry season and enhance capability to withstand natural disasters.

Therefore, the attributes of HHRT's OUV are mainly contributed to by Hani's water utilisation system to a great extent because water is an integral element to the farming terraces. Specifically, attributes of water heritage demonstrate the spiritual, institutional and technical aspects of living and farming, and integration of Hani water culture, water utilisation pattern, technical infrastructure, management and social regulations thanks to its special conditions of climate and topology here. Furthermore, the overall water heritage in HHRT could be water management system, landscape related to water, Indigenous knowledge of water use in the agricultural system, and traditional customs and worship ceremonies of water. This is a common framework for every traditional village, but it is somewhat specific for each village. For example, Yakou village has the most integrated and systematic water woods system due to its high altitude, which is the key tool for allocating water resources to different paddy fields. However, Dayutang Village has the most complete water heritage because of its well-conserved traditional water committee.

2. State of conservation and management of water heritage

Water heritage of HHRT is still used. Forests, terraced paddy fields and canals are closely related to people's livelihood and eery effort is, therefore, made to conserve them. Access to the forests for water is forbidden due to religious tradition and people are not allowed to collect firewood in this area either; they must collect firewood in forests that are particularly allocated to firewood instead. Recently, through forests planting to conserve water and the system, the percentage of forest coverage is about 70 per cent in property area, and there are almost 500 trunk canals (including water woods and adjustment stones) in use and under regular investigation. Most community infrastructure and sanitation facilities have been effectively implemented. The basic farmlands are protected and subsidised, and the driving force is enhanced through support for traditional ecological production and development policies. This helps farmers to earn more income from farming traditional red rice and rural tourism, which is encouraged by local authorities. Some of the terraces were destroyed by landslide and mudflow in recent years due to strong rainfall but have been recovered by local communities and with the cooperation of many sectors.

Figs. 6a-6b: Water Woods and canals to distribute water in Yakou Village. © *Li Yuxin.*

Traditional red rice usually grows at altitudes of 1200–1900 m. According to statistical data of 2020, the area is about of 400,000 ㎡ in Yuanyang County, 1,333-2,000 ㎡ terraced fields per household. The selling price is about 28 yuan/kg in the market, higher than before inscription.

3. Legal protection in force

The legal protection of Hani Rice Terraces and its water heritage are comprised of two parts: the modern legal system, and the traditional customary laws and village regulations. From 2000 to 2013, the HHTR World Heritage Administration and the Yuanyang Management Committee for World Heritage HHTR enacted a modern law and regulatory system to promote the protection and sustainable development of the rice terraces based on local customary laws, such as traditional regulations on forest protection and water resources use. They have drafted local laws, regulations and administrative measures. While using and maintaining the customary laws and village regulations, the conservation and management of the rice terraces are conducted according to the law and are gradually being integrated into the modern legal framework. At the same time, they formulated conservation and management plans which were announced by the State Council and provincial people's government so it could be incorporated into the national legal protection system. This would allow them to obtain State financial support.

4. Threats to water heritage

The water heritage of HHRT is exposed to climate change. Extreme climate events have occurred frequently in last two decades. The drought from the year of 2009 to 2014 in Yunnan province and heavy rainfall in recent years have impacted on Hani Rice Terraces with evident water shortages or landslides in some fields. Urbanisation and change of lifestyle are challenging the traditional water utilisation patterns as well. The unclear power and responsibilities in canal management and terrace maintenance also reflect the incomplete legislative framework and village planning in integrating the traditional society into a modern society. The decreasing farm population and young part-time farmers are common threats in most agricultural systems, because of the decrease in farming income.

5. Conclusions

The water heritage in Hani Rice Terraces is closely associated with water's integral role in sustaining the livelihood of local people. It has provided basic living provisions and shaped the agricultural system. Therefore, the effective operation and allocation of water resources by local people have created a unique form of water heritage. This case study summarises the attributes of water heritage contributing to the OUV of HHRT and concludes that the water heritage of HHRT functions in both ecological and socio-cultural aspects, but it is challenged by the global climate change, the decrease in the number of farmers and younger part-time farmers, urbanisation, incomplete management systems and village planning in integrating the raditional society into a modern society.

The principle of integrated conservation and classification protection should be followed to conserve the water heritage,. In order to conduct dynamic management activities in the living heritage, a systematic survey project and water heritage recognition in the property area and digitising of data of the sites based on GIS need to be carried out. After that, detailed planning related to irrigation and rights and responsibilities of lands and canals could be clarified and perfected in planning and regulations.

Meanwhile, restoring key elements of the attributes, supporting self-governing traditions and specialised conservation organistions, promoting traditional cultural festivals and ritual activities, innovations and involvement of multiple parties and collaborative management are crucial.

* * *

06. China: Central China

Regional overview: Central China of Yangtze River

By Zhang Nianqiang, Professor of China Institute of Water Resources and Hydropower Research

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1. General characteristics

Central China of the Yangtze River mainly includes Hubei, Hunan and Jiangxi provinces, as well as the southern part of Anhui and Henan provinces.

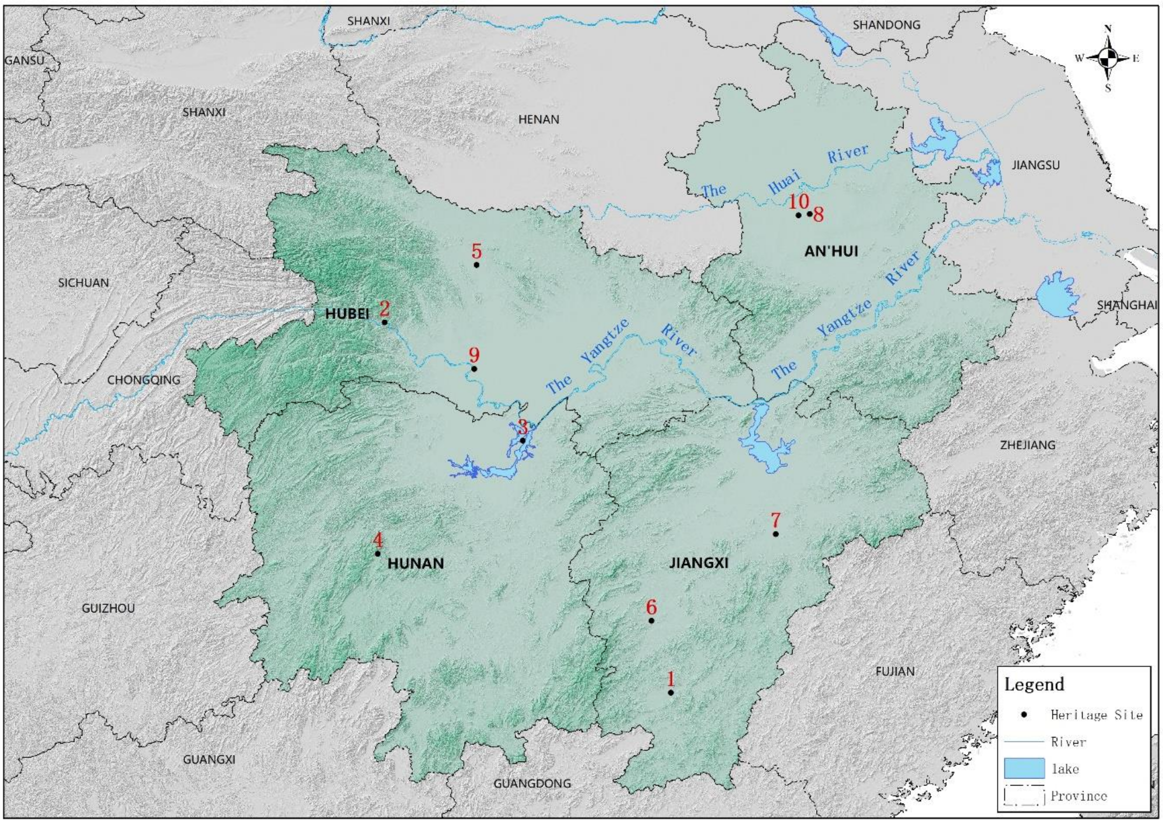


Fig. 1: A map of the Central China Yangtze River: (1) Fushou ditch site, (2) Hydrological inscriptions along the Yangtze River, (3) Polder field irrigation project of Dongting Lake, (4) Ziquejie Terrace, (5) Changqu Channel irrigation engineering system, (6) Chatanbei pond irrigation engineering system, (7) Qianjin pond irrigation engineering system, (8) Flood wall of Shouxian Old City, (9) Flood control system of Jingjiang Levee, (10) Quebei irrigation engineering system. © *Zhang Nianqiang.*

1.1. General climatic data and general hydrological data

The Yangtze River is the largest river in China, with a total length of more than 6,300 kilometres, ranking third in the world after the Nile and the Amazon. The middle reaches of the Yangtze refer to the river and lake systems between Yichang and Hukou, including the main stream of the middle reaches of the Yangtze River, Dongting Lake, Hanjiang River, Poyang Lake system and other lakes distributed on both sides of the Yangtze River, as well as some tributaries directly flowing into it.

In the middle reaches of the Yangtze River Basin, the plain area accounts for a large proportion, except that the upper reaches of its tributaries are hilly areas. In this region, winter is cold and summer is hot, and the annual temperature range is large. The difference between the average temperature of the hottest month and that of the coldest month is obvious. There is abundant rainfall, and its spatial and temporal distribution is uneven. In spring, the warm and wet air flow from the south is gradually transported northward, which makes the southern part of the area enter the flood season in April or earlier. From June to July, the Meiyu rain area is broad and the rainfall is concentrated. From July to August, floods occur frequently in the upper reaches of the Yangtze River. The main stream of the middle reaches collects the water from the tributaries of the upper reaches and the middle reaches of the Yangtze River. The annual maximum water level often appears during this period, which makes it the main flood season of the middle reaches of the Yangtze River. After October, the flood season basically ends.

The middle reaches of the Yangtze River is the most concentrated area of lakes in the whole basin. Poyang and Dongting Lakes are the largest and the second largest freshwater lakes in China. These lakes have a role in regulating and storing flood water, as well as irrigating farmland. Therefore, the middle reaches of the Yangtze River is the main Chinese base of grain, cotton and aquatic products, and has become a land of fish and rice.

1.2. Cultural relations and technical exchanges with neighbouring zones

During the Spring and Autumn period and the Warring States Period (770 BC–221 BC), the state of Chu made great efforts to develop the Yangtze River and Huaihe River areas. The construction of ponds was the most successful and its engineering technology took a qualitative leap forward. Sun Shuao, the prime minister of the state of Chu, presided over the establishment of Yulou Irrigation Area, which is the first large-scale irrigation canal system project in China. In fact, this is the application and development of paddy field irrigation and drainage technology of the Yangtze River Basin in Huaihe River Basin.

During the Han Dynasty, great importance was attached to the development of the southern region. A number of large and medium-sized pond project systems emerged in the middle and lower reaches of the Huaihe River and the Yangtze River. In the Eastern Han Dynasty（25–220), the capital was moved to Luoyang, and Nanyang, Henan Province, which is located to the south of Luoyang. This is where Emperor Guangwu, the founding emperor of the Eastern Han Dynasty, grew up. Therefore, its political and economic status is very important. The construction of ponds here has been the subject of attention and has gradually extended to the south of Lujiang River and Yangtze River in Anhui Province. At the end of the Eastern Han Dynasty, the northern part of China was in a state of war, where the political situation was turbulent and the economy was in decline, which led to the first large-scale southward migration of population in Chinese history, thus promoting the large-scale development of the middle reaches of the Yangtze River. During the Wei, Jin and Southern and Northern Dynasties (220–589), China was divided for a long time. The area between the Yangtze River and Huaihe River was where the northern and southern regimes competed with each other. With the development of the military garrison, more and more ponds were built. During this period, the farming activities in the middle reaches of the Yangtze River and the coastal areas of Ganjiang River, Fuhe River and Poyang Lake gradually increased; the Yangtze River and its tributaries Ganjiang, Xiangjiang and Hanshui Rivers gradually became the main water transportation trunk lines, and the river basin water transport network gradually formed; today's cities of Changsha and Jiujiang began to become regional political and economic centres, the cities of Hankou, Nanchang and Jiujiang developed into prosperous ports.

After the armed rebellion led by An Lushan and Shi Siming in 755–763 in the Tang Dynasty, the war spread throughout the middle and lower reaches of the Yellow River, while Jiangnan Region (namely the area south of the Yangtze River) was relatively stable. As a result, a large number of people moved from the north to the south, which not only increased the population of the Jiangnan Region rapidly, but also brought a large number of workers and advanced technology. During this period, the imperial government attached great importance to the development of Jiangnan Region because its financial revenue mainly depended on it. With the large-scale reclamation of low-lying plain, hilly and mountainous areas in the Yangtze River Basin, water projects such as ponds, weirs, dams and dikes were developed rapidly, and this effectively promoted the economic and social development of Jiangnan Region, with the subsequent shifting of China's economic centre to the Yangtze River Basin.

In 1127, the army of the Jin Dynasty broke Kaifeng, the capital of the Northern Song Dynasty. The royal family of the Song Dynasty crossed the Yangtze River to the south and established its capital in Hangzhou, Zhejiang Province, which was known as the Southern Song Dynasty. As a result, a large number of people and advanced technology from the north poured into the Yangtze River Basin. The Southern Song Dynasty was located in Hangzhou, which put forward further requirements for the economic development of the south of the Yangtze River; in addition, with the development of the mountainous areas in the upper reaches of the Yangtze River, the deposition of rivers and lakes accelerated, all these factors jointly promoted the great development of water conservancy in the Yangtze River Basin. At that time, the irrigation water conservancy of Anhui, Jiangxi, Hubei, Hunan and other provinces in the middle reaches of the Yangtze River, as well as Poyang and Dongting Lake areas, developed rapidly. But generally speaking, polder fields in Poyang Lake, Dongting Lake and central Anhui plain were the mainstream of irrigation engineering development in this period. Some low-lying areas became polder fields with stable and high yield. Meanwhile, projects of water diversion irrigation and water storage irrigation were still developing. After the central government of the Northern Song Dynasty promulgated *The Farmland Irrigation Treaty*, new irrigation projects appeared constantly, and many old ones showed greater benefits after renovation, transformation and expansion.

During the Ming and Qing Dynasties, the population of the southern provinces increased rapidly, and the contradiction between more people and less land was becoming more and more serious. Due to the intensification of land annexation and frequent flood and drought disasters, a large number of poor people who lost their land moved to the lake area in order to survive. This is when large-scale reclamation of the lake began. Reclamation activities were mainly concentrated in Jianghan Plain, Dongting Lake Plain, Poyang Lake Plain and the lower reaches of the Yangtze River. In order to defend against the high-level flood of the Yangtze River and its tributaries, the local people had to ensure that the dikes of the polder fields they were building were tall and strong and had to continue to manage the polder areas. The main dikes of the Yangtze River, such as Jingjiang Levee, Hanjiang, Wuhan and Huangguang dikes in Hubei Province, Tongma dike and Wuwei dike in Anhui Province, were mostly built during this period.

2. Known and important sites for the cultural heritage of water

2.1. Archaeological sites

2.1.1. Fushou Ditch site in Ganzhou City, Jiangxi Province

Fushou Ditch, located in the underground of the old urban area of Zhanggong District, Ganzhou City, Jiangxi Province, was planned and constructed by Liu Yi during the Xining Period of the Northern Song Dynasty (1068–1077). He built Fu Ditch and Shou Ditch according to the city scale, street layout and terrain characteristics, and took them as a drainage trunk system; he also built a branch ditch system. The catchment area of Fushou Ditch is roughly bounded by Wenqing Road. The rainwater from the east of Wenqing Road flows into Fu Ditch and discharges into Gongjiang River; the rainwater from the west flows into Shou Ditch and into the Zhangjiang River.

Fushou Ditch is more than 900 years old. However, it is still intact, and continues to be the main channel for the daily sewage discharge of Ganzhou residents. The total length of the existing original trench is not less than 12.6 km, and at least 1.9 km still retains the ancient shape and materials. According to the surveyed results, the main ditch is 1,066.4 metres in total and the branch ditch is 37.5 metres in total. The main trench is 0.7–1 metres wide and 1.1–1.35 metres high, with a blue brick arch top, masonry side wall and flat bottom. It is well preserved, and the original structure and materials are still retained, and play normal roles.

The flood control system of Ganzhou Old City is generally composed of the old city walls of Ganzhou. The old city wall is used to directly prevent inundations caused by flood waters into the city. The drainage system of Fushou Ditch can successfully discharge the rainwater from the city and regulate and store the rainwater by connecting the water storage ponds. The most important part of the drainage system is its drainage ditch, water gate, water inlet hole, well-sinking and other facilities. According to the map of Fushou Ditch drawn during the reign of Emperor Tongzhi of Qing Dynasty (1861–1875), the total length of Fushou Ditch is about 12.6 km, of which Shou Ditch is about 1 km and Fu Ditch is about 11 km. It has an arch and rectangular cross section, and the upper ditch top is designed as a brick arch structure, which can effectively bear the load, prevent the collapse of the ditch top, and prevent the river water from flowing backwards. The money-shaped-water-inlet-hole can effectively collect rainwater on the ground, which is beautiful and prevents blockage. Well-sinking can prevent silting up. The whole system is very similar to modern drainage facilities. In general, Fushou Ditch has the following characteristics in planning, layout and engineering technology: 1) regional drainage and shorter drainage distance, 2) the layout of drainage fully considers the trend of the terrain and has a large section drainage ditch, 3) the drainage pipeline is constructed with a one-way flow device similar to the flapper to prevent the river floods from flowing backwards, 4) Fushou Ditch connects many ponds in Ganzhou City, forming a water network for joint flood control and storage.

2.1.2. Hydrological inscriptions along the Yangtze River in Hubei section of the Three Gorges Project

Hubei reservoir area of the Three Gorges Project of the Yangtze River is located in Xiling Gorge and Wuxia area. During thousands of years of fighting against floods and droughts, the local people recorded the flood and low water level of the Yangtze River, waterway regulation, warning of navigation-hampering shoals, expectation of river stability and other contents on the rock walls on both sides of the Yangtze River by means of engraving stones. These inscriptions are a database of water level changes and the water conservancy management process in the Three Gorges area and even of the whole Yangtze River basin.

Hydrological inscriptions of Xiajiang River

In the Hubei section of the Three Gorges Project, there are many inscriptions recording the historical flood level of the Yangtze River and they are widely distributed. According to the survey, there are 23 flood inscriptions on both sides of the Yangtze River, recording 8 historical floods in the upper reaches of the Yangtze River. The inscriptions are now in Huangling Temple, located in Sandouping Town, Yichang County, Hubei Province, where a large number of precious hydrological inscriptions and material objects about the flood level of the Three Gorges are preserved.

Inscriptions on harnessing shoals and rivers

There are many dangerous sections in Xiling Gorge of the Yangtze River, among which Xintan Shoal in Zigui County, Hubei Province, is the most famous. There are many documents about the regulation of Xintan River in history, among which many inscriptions recording the regulation of dangerous beaches and dredging the waterway at that time are the most precious. In Jiangdu Temple, on the south bank of Xintan Shoal, there is a stone inscription recording the dredging of Xintan River, which is the only one existing on the rockfall disaster and its treatment process of Xintan.

Inscriptions on leading ships and guiding waterways

The Yangtze River channel is full of waves, fast currents, reefs and great risks to sailing, so local people have left many inscriptions about leading ships or guiding waterways along the Three Gorges. Among them, two are famous. The first is the ‘Thunder Hole’ stone (fig. 2) carving located at Tuotan Shoal, the other one is the ‘Come to me’ cliff carving, located in Miaohe Village, Mao Ping Town, Zigui County, on Dazhu Cliff in the heart of the Kongling Shoal section. They are all used to guide ships and help them avoid hitting rocks and sinking.

Fig. 2: ‘Thunder Hole’ reef and its inscription, taken from *Selections of the Inscription in the Three Gorges Dam, Hubei. © Changjiang Water Resources Commission of the Ministry of Water Resources.*

2.2. Living sites

2.2.1. Polder field (Weiyuan) irrigation project of Dongting Lake

Polder fields of Dongting Lake are located in Hunan Province, which is defined as farmland surrounded by dikes in low-lying and waterlogging-prone areas around rivers and lakes. It is called Wei in the lower reaches of the Yangtze River and Yuan in the middle reach, collectively referred to as Weiyuan. The polder fields of Dongting Lake are the most representative and are characterised by large areas, high dikes, many shallow lakes, few ditches, and great variation in the flood and dry water levels.

The earliest reclamation of Dongting Lake can be traced back to ancient times and has a history of more than 6,000 years. However, clear records of building polder fields began in the Song and Yuan Dynasties (960–1368), and these have experienced construction and repair over the generations. By 1999, there were 37 polder fields over 667 hectares, of which 15 were over 6,670 hectares.

The construction of polders has effectively promoted the development of an agricultural economy in Dongting Lake area, making it an important food production base. However, it has also led to the shrinking of Dongting Lake area and damaged its ecology, which in turn has had certain negative effects. In 1825, the area of Dongting Lake was about 6,000 km², and its volume was about 40 billion m^3. By 1949, this had reduced to 4,350 km² and 29 billion m^3 respectively. By 1983, the area of Dongting Lake was further reduced to 2,691 km² and its volume was further reduced. This trend was not alleviated until 1998 when ‘restoration from polder field to lake’ policy was implemented.

2.2.2. Ziquejie terrace in Hunan Province

Ziquejie Terrace, located in Xixi District of Shuiche Town and Shuanglin District of Fengjia Town, Xinhua County, Loudi City, Hunan Province, have more than 3,733 hectares of terraces. They are distributed along the mountain, ranging from 500 metres to 1,100 metres above sea level, with a total of more than 400 levels. The average gradient of terraces is about 30 degrees, and the steepest is more than

50 degrees. The largest field is less than 0.067 hectares, and the smallest one can only be planted with a few dozen seedlings. It is characterised by its large scale, large quantity, steep slope, small field and beautiful shape.

The formation of Ziquejie Terrace has a history of 2,000 years, originating in the Pre-Qin Period and flourishing in the Song and Ming Dynasties. It was created by Miao, Yao, Dong and Han and other ethnic groups. It is a historical heritage of the integration of fishing and hunting culture and rice culture in mountainous areas and a prominent symbolic cultural landscape in the ancient Meishan area.

Ziquejie Terrace is mainly paddy fields, supplemented by dry land. For thousands of years, the traditional farming methods adapted to the environment have been formed and they are still widely used. The development of Ziquejie Terrace benefits from its special geographical conditions. The groundwater here belongs to the type of bedrock fissure pore water, which flows by itself from the bedrock fissure. This means that local people creatively adopted a variety of techniques, such as water source, water storage, water conservation, water delivery and irrigation, and realised effective gravity irrigation with simple engineering facilities, and gradually developed a set of scientific water management methods, which were passed down from generation to generation. According to the local topographic conditions, they designed the length, width and step height difference of each terrace, so as to ensure that each terrace could have sufficient water source and good hydraulic conditions, and prevent negative effects such as soil erosion, and effectively control drought disasters.

The irrigation engineering system of Ziquejie Terrace consists of three parts: water storage project, irrigation and drainage canal system, and control facilities. The terraced fields here are mainly irrigated by diverting streams, and spring water irrigation is limited to the fields on their edges. Terraces are as high as the stream water. When irrigating, dams are built on mountain streams to divert their water, which is sent to terraced fields through water conveyance channels. Irrigation between terraces at all levels adopts the way that streams pass through the fields and connect them in series. In order to prevent the collapse of the ridge caused by current scour when a stream flows from a terrace to its lower terrace, bamboo is used as a small aqueduct (local people call it Zhujian) through which the water can be sent to a position far away from the foot of the ridge, so as to ensure that all terraces can be irrigated by gravity (Figs. 3a-3b).

Figs. 3a-3b: Borrowing fields for water conveyance: terraced fields are also water channels. © *Wei Jianguo & Wang Ying*

2.2.3. Quebei Irrigation Engineering System in Anhui Province

Quebei Irrigation Engineering System, also known as Lujiangbei Pond, Qisibei Pond, Longquanbei Pond and Anfeng Pond, is located in the middle of Anhui Province, on the south bank of the middle reaches of Huaihe River, 30 kilometres south of Shouxian County, Anhui Province. It was built in the period of King of Chu Zhuang (601–593 BC) in the middle of the Spring and Autumn Period by Sun Shuao, who was the prime minister of Chu State, around 600 BC. It is a typical pond water storage and irrigation project with a history of more than 2,600 years.

Quebei Pond Irrigation Engineering System is composed of pond dikes, mouth gates, diversion channels and drainage ditches. It acts as water storage, flood regulation and drainage, etc. The pond dikes are the main projects of Quebei Pond, and its huge water storage capacity completely depends on them. The mouth gates are buildings for water intake, diversion and discharge. The water diversion and drainage channels are connected with the mouth gate. Water can be taken from Quebei Pond River to irrigate farmland. Because of its water storage function, Quebei Pond plays a role in irrigation, supplying water for Shouchun City, regulating the amount of water in transportation channels and storing mountain torrents.

Quebei Pond makes full use of the local topography and water source conditions. It has scientific site selection, ingenious design and reasonable layout, which perfectly embodies its construction concept of respecting nature, conforming to nature and integrating into it. The terrain around Quebei Pond is high in the east, south and west, low in the north, and inclines towards the Huaihe River. When mountain torrents occur in the rainy season, waterlogging often occurs here, and drought often occurs when there is less rain. Taking advantage of the situation, Quebei Pond used the difference of terrain to build the dike of the pond, bringing together the streams of Jishi Mountain in the east, Longchi Mountain in the southeast and Longxue Mountain in the west. The water quantity of Quebei Pond is controlled by building five stone gates. When the water level rises, the gates are opened to discharge water, and after the flood, the gates are closed to store water. This not only ensures that there is water to irrigate the field in case of drought, but also avoids flooding and waterlogging when there is too much water.

In the historical period, the construction of Quebei Pond promoted agricultural development in the middle reaches of the Huaihe River, making it an important grain-producing area in China, with an irrigation area of 10,000 hectares at most. Now, Quebei Pond is included in Pishihang Irrigation Area, which is a model of a sustainable irrigation project in the middle reaches of Huaihe River. The existing Quebei Pond is the remains of the ancient Quebei Pond after sedimentation and shrinkage, with a circumference of 25 kilometres, a water surface area of 34 km^2, a water storage capacity of about 73 million m^3 and an irrigation area of 42,000 hectares. In October 2015, Quebei Pond was included in the World Irrigation Project Heritage List.

2.2.4. Changqu Channel irrigation engineering system in Hubei Province

Changqu Channel, also known as Baiqi Channel, extends from Xiejiatai Village in Nanzhang County, Hubei Province in the west, to Chihu Lake in Yicheng City in the east and flows into the Hanjiang River. It is 49.3 kilometres long and was built in 279 BC; it is one of the oldest water diversion projects in China.

In the history of water conservancy in China, the Changqu Channel has created the irrigation mode of connecting ponds and canals to form a network system and the system of irrigation by turns in different periods.

First of all, in terms of engineering construction, the Changqu Channel adopts the traditional Chinese bamboo cage engineering technology, that is, a barrage is built on the Manhe River by filling bamboo cages with stones and filling their gaps with soil, so that it cannot only resist the impact of floods, but also discharge water and adapt to changes in the riverbed. This technology is similar to the Feishayan barrage in Dujiang Weir.

Secondly, in terms of irrigation mode, the Changqu Channel creates an irrigation mode in which ponds and channels are connected in series. Since then, the local people have not only connected the existing ponds by channels, but also built 49 new ponds along the channels. At the same time, many branch canals were excavated to form an irrigation canal system with the main canal, branch canal, bucket canal and agricultural canal connected with each other, so that there is a wider range of water allocation. If the weir at the head of the canal is compared to the 'root of a melon', then the channels are the 'vines of the melon', and the numerous ponds connected by the channels are the 'melons' on the vines, which is called melon-on-the-vine irrigation system.

Thirdly, from the aspect of a water management system, a water gate is used to control water distribution. According to records, there are 46 water gates in Changqu Channel, which are used to control water diversion and water quantity and formulate the system of irrigation by turns in different periods. There are four large sluices on the Changqu Channel, which divide the irrigation area into four sub-regions, and these take turns to irrigate from upstream to downstream. A round takes 9 days (216 hours): the water supply time in the upstream sub-region of the first sluice is 48 hours, that of the second sluice is 56 hours, that of the third sluice is 50 hours, and that of the fourth section is 54 hours. The free time for maintenance and overhaul is 8 hours.

Currently, the Changqu Channel irrigation engineering system uses Sandaohe Reservoir, a large reservoir, as its main water source. It has 15 reservoirs connected in a series and 2,671 ponds as its supplementary water sources, and all levels of trunk and branch channels as its vein and continues to function. In 2018, the Changqu Channel was listed in the World Irrigation Project Heritage List.

Fig. 4: Changqu Channel. © *Liu Jiangang.*

2.2.5. Chatanbei Pond irrigation engineering system in Jiangxi Province

Chatan Pond irrigation engineering system is located in Taihe County, Ji'an City, Jiangxi Province. Its dam is located on Niuhou River, a secondary tributary of the Ganjiang River. The rainfall collecting area above it is 971 km². Chatan Pond was founded by Zhou Ju in the Southern Tang Dynasty. It was built in 958.

Chatanbei Pond is divided into two parts, the main and the auxiliary dams. It is composed of a raft road, a sand discharge gate, a diversion channel, a flood dike and a general intake gate. The elevation of the main dam crest is 78.8 metres, the length is 105 metres, the elevation of the auxiliary dam crest is 78.5 metres, the length is 152 metres, and the raft road is 7 metres wide. The canal flows through Heshi Town from west to east. In Shangjiang Village, it is divided into two tributaries, namely South Main Canal and North Main Canal, and then flows through Luoxi town and Shishan township and flows into Heshui in Sanpai Village. At the base corner of the main dam, a large number of exposed red stone strips are the earliest dam building materials, which are stacked in four or five layers. Each stone is 4 metres long, 0.4 metres wide and 0.5 metres thick.

Fig. 5: Chatanbei Pond. © *Liu Jiangang.*

In addition to the dam project, in order to achieve the purpose of irrigation, at the beginning of the project, Zhou Ju and his son led villagers to dig 36 irrigation channels to provide water for 600 hectares of drought-stricken farmland in Heshi town and other places. Due to the perfect management system of the ancient water conservancy project, this water conservancy project still has irrigation benefits. After continuous expansion and maintenance, it now undertakes the irrigation work of nearly 3,335 hectares of farmland along the coast.

In 2013, Chatanbei Pond was included in the list of National Key Cultural Relics Protection Units. In November 2016, it was included in the World Irrigation Project Heritage List.

2.2.6. Qianjin Pond Iirigation engineering system on Fuhe River in Jiangxi Province

Qianjin Pond irrigation project was built in the ninth year of Xiantong of the Tang Dynasty (868), and then expanded and repaired continuously until the Ming Dynasty. It is the largest, longest lasting and most far-reaching comprehensive water conservancy project in Fuzhou history, and it is also the largest river guidance project of gravity-type dry masonry in China.

Qianjin Pond is built on Fuhe River, a tributary of Poyang Lake in the Yangtze River Basin. It is a masonry dam with a total length of 1.1 kilometres and a top width of more than 10 metres. Each block is about 2 metres long and about 50 centimetres wide and high. The end of the dam connects with Zhongzhou Polder.

Qianjin Pond lies in the water in the shape of a dragon. It uses the 'dragon body' to block water to raise the water level and slow down the flow rate. The water of Fuhe River is diverted into the irrigation area to ensure the water use of Zhongzhou Polder. At the same time, it plays an important role in the flood control of Fuhe River, and the urban water environment restoration and water transportation of Fuzhou city.

Influenced by the development level of productivity and flood, Qianjin Pond has experienced more than 10 different reconstructions and repairs from the Tang to Qing Dynasties. The existing project is a masonry structure constructed more than 400 years ago. After the founding of the People's Republic of China, the dikes of Qianjin Pond on both sides of the Fuhe River and its tributary port were raised and reinforced using modern technology, and the urban-area dike was transformed into an important traffic road along the river.

2.2.7. Flood wall of Shouxian Old City in Anhui Province

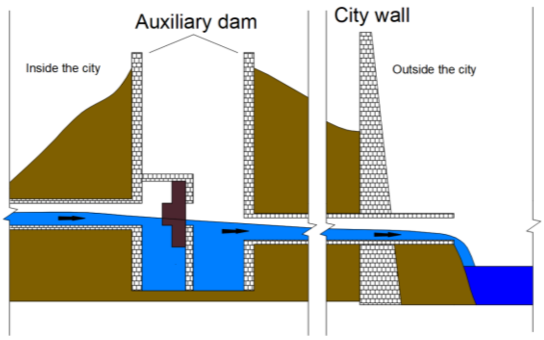
Shouxian Old City, also known as Shouchun, is located in Huainan City, Anhui Province, on the south bank of the Huaihe River. It was built in the Song Dynasty (1068–1224) and is a chessboard-style city with a total area of 3.65 km^2. Since Chu State moved its capital here in the 22nd year of King Kaulie (241 BC), Shouxian City has been a county 10 times.

Shouxian Old City is slightly square, with a circumference of 7,141 metres, a height of 8.3 metres, a bottom width of 18-22 metres and a top width of 4-10 metres. Its walls are rammed with soil, with bricks on the outside, and a 2-metre-high stone foundation at the lower part of the outer wall, which is inclined inward. The external thickness of the city walls is about 15 metres at the bottom and 0.5-0.8 metres at the top. In the east and south of the city, there are moats about 60 metres wide. The north of the city is surrounded by the Feishui River, and the west of it is connected with Shouxi Lake. At the foot of the outer wall, there is a stone dike about 8 metres wide. There are four gates in the Old City, all of which are connected with Urn City (enclosure outside the city gate). There are eight turrets in the city, all of which have collapsed.

Figs. 6a-6b: The East gate and Urn City of Shouxian Old City. (a) Outside (b) inside (Urn City).
© *Zhang Nianqiang.*

Historically, Shouxian City was seen as having strong flood control and military defence functions. If we take Urn City as an example, a fierce flood cannot directly rush to the inner gate after breaking through the outer gate, but instead it forms an eddy current inside Urn City, which can greatly reduce the pressure on the inner gate and protect the city. In terms of military defence, it can make the enemy lose the target of attack immediately after breaking the first gate, which is convenient for the defenders on the rostrum to 'catch turtles in the urn'.

Yue Dam was another typical flood control project. It was a cylindrical dam wall of masonry structure built on the culvert, with stone steps extending to the dam bottom on the inner wall. Bricks were laid on the culvert at the dam bottom, and several gates were set into this. The main functions of the Yue Dam are as follows: first, protect the culvert gate from being damaged by the accumulated water in the inner city river; second, managers can enter the dam at any time to open and close the culvert gate, so as to control the flow freely; Third, the water level difference between inside and outside the city can be compared in time by observing the culvert mouth; Fourth, even if the external water is poured backward, it is accumulated in the Yue Dam, which can basically eliminate the hidden danger of flood.

Figs. 7a-7b: The whole view of the culvert and a schematic diagram of its operation principle. © *Zhang Nianqiang & Li Yunpeng.*

2.2.8. Flood control system of Jingjiang Levee

Jingjiang Levee refers to the left bank of Jingjiang River, starting from Zaolingang in Jiangling County to the south of Jianli County, with a length of 182.35 km. Currently, it protects the vast Jingbei plain area and maintains the flood control safety of 5 million people and 530,000 hectares of cultivated land, as well as many towns and other important resources. It has been listed as the key flood control project of the Yangtze River.

The Jingjiang Levee was first founded in the Yonghe Period of the Eastern Jin Dynasty (345–356). At that time, the dikes on both sides of the Jingjiang River were constructed in sections by counties. As a scientific planning idea, many diversion outlets on both sides were reserved. This is mainly due to the low-discharge capacity of Jingjiang River. It is far smaller than the flood caused by the flood peak of its main stream. The excessive flow can be discharged through diversion outlets on both sides; water to the south could flow into Dongting Lake for regulation and storage.

In the Qing Dynasty, the dikes were continuously extended and raised, and the dikes in Jiangling, Jianli and Mianyang on the north bank of the Jingjiang River were more than 300 kilometres long. The dikes in Jiangling, Gongan and Shishou on the south bank of it are more than 150 kilometres long, and the other branch river dikes are also hundreds of kilometres long. In 1951, the 8.35-kilometre dike in the upper reaches of Duijintai and the original 50-kilometre dike in the lower reaches of Jingjiang Levee were classified as Jingjiang Levee, which formed the Jingjiang Levee of today. At present, the entire Jingjiang Levee belongs to Class I levee, and its body, foundation, revetment and culvert gate are designed according to Class I buildings. During this period, the actual flood in 1954 was taken as its flood control standard, the Jingjiang River Flood Diversion Project was built in 1952, and it was included in the national infrastructure investment project for reinforcement in 1974. At present, through the joint dispatching of the Three Gorges Project and the comprehensive application of its downstream flood diversion and storage areas, the flood control safety of Jingjiang Levee can be basically guaranteed.

3. Existing documentation

In this region, the reference lists mainly include the World Irrigation Project Heritage List Units, and the Chinese Important Agricultural Cultural Heritage List.

The Yangtze River Basin has a long history of water control. In the long-term practice of fighting against flood and drought, local people along the Yangtze River had left much long-term hydrological data about the flood and dry water level of the Yangtze River by means of historical documents and stone inscriptions. Among these materials, hydrological inscription is not only of high data value, but also a precious water heritage. Among the local hydrological inscriptions, the inscriptions along the Three Gorges section of the Yangtze River are the most famous. *Hydrologic Inscription Cultural Relics in Three Gorges Reservoir Area* and *Selections of the Inscription in the Three Gorges Dam, Hubei* are the most representative compilations of the survey results. The former mainly includes 397 photos of flood and low water inscription in the Three Gorges reservoir area, which basically covers all hydrological inscriptions in the Three Gorges reservoir area, including many hydrological inscriptions in the middle reaches of the Yangtze River. The latter mainly includes hydrological inscriptions in Hubei section of the Three Gorges. These inscriptions play an important role in hydrological history because of their age, quantity and wide distribution.

The early maps about the middle reaches of the Yangtze River are mainly of two types: the first type is the ancient map, which is the most abundant and representative in the Ming and Qing Dynasties. Among them, some are included in the maps of the whole line of the Yangtze River, such as *the map of the Yangtze River* in the Qing Dynasty, etc. Some are specially related to the water system and water conservancy projects in the middle reaches of the Yangtze River, such as *the Map of Jiujiang Prefecture*, *the Map of Poyang County*, and *the Map of Hanjiang Levee* in the Qing Dynasty, etc. The second type is the modern surveying map. For example, the surveying maps of Hanjiang River and Jinshui River in Hubei Province by the Yangtze River Waterway Arrangement Committee of the Ministry of Communications.

The ancient documents about the middle reaches of the Yangtze River mainly focus on the following two aspects: one is the textual research of the Yangtze River system. For example, *Research on the Origin of the Han River* mainly contains historical materials about the origin of the Han River; the *Research on the Origin and Development of Various Rivers in Southern Chu State* is a monograph on the textual research of Xiangjiang River and Jiujiang River System in the ancient Chu area; and *Research on Jiangxi Watercourse* focuses on the Yangtze River, Ganjiang River, Pengli Lake and other river and lake water systems in Jiangxi Province. *The Records of Dongting Lake*, written in the Qianlong period of the Qing Dynasty, is the first and only ancient local record about Dongting Lake, and it is also the first-hand material for studying Dongting Lake. The second consists of records about the Yangtze River water conservancy project. Among them, there are many articles in the literature about the harnessing of the Hanjiang River. *Records of Wancheng Dike in Jingzhou County* and its continuation records etc. are the first special local records recording the north bank dike of the Jingjiang section in the middle reaches of the Yangtze River. *Record of Li Channel*, written by Cao Shuyuan in the Southern Song Dynasty, specifically records that Li Jiangshun, the governor of Yuanzhou during the Tang Dynasty, excavated channels, supplied water to Yichun City and irrigated farmland for a long time.

The local records about the middle reaches of the Yangtze River mainly refer to the provincial chronicles of Hubei, Hunan, Jiangxi and Anhui provinces, as well as the county records along the Yangtze River in these provinces. There are many records about the reconstruction, expansion and management of the Yangtze River since 1949 in the local records of water conservancy.

Among the travel works about the Yangtze River, the works of Lu You and Fan Chengda, famous poets in the Southern Song Dynasty, are the most representative. In the book of *Records on Entering Sichuan* by Lu You, the author recorded what he saw or heard about the natural and cultural landscapes and folk customs of six provinces and cities in Zhejiang, Jiangsu, Anhui, Jiangxi, Hubei and Chongqing on his way from Zhejiang to Sichuan via the canal and the Yangtze River, many of which were about rivers and water conservancy projects in the middle reaches of the Yangtze River. In the book of *Records of Ships of Wu* by Fan Chengda, the author recorded the natural landscapes and historical sites he saw or heard on his way from Chengdu, Sichuan Province, along the Yangtze River waterway to Hangzhou, Zhejiang Province, such as Dujiangyan, Leshan Giant Buddha, Three Gorges of the Yangtze River, Dongting Lake, Chibi, Lushan, etc.

4. State of historic and technical knowledge concerning water heritage in the sub-region

4.1. During the Neolithic Age

A large number of rice husks and rice grains were found in the Pengtoushan site, Lixian County, Hunan Province, more than 8,000 years ago, and these may be early cultivated rice. The Daxi Culture, 7,000 years ago, indicated that rice farming had developed to the southwest of Jianghan Plain and the north of Dongting Lake. Three water pits were found in the original soil layer on the west side of the paddy field, and two small ditches were found which flowed into the No.1 pit from southwest to northeast. These water pits and ditches are undoubtedly the supporting facilities for paddy fields. Therefore, the middle reaches of the Yangtze River had a primitive irrigation system as early as 6,000 years ago. Large-scale settlements and farmlands developed in the lowlands were found in the sites of Qujialing culture and Shijiahe culture from 5,000 to 4,000 years ago.

4.2. From Xia Shang Zhou to Spring and Autumn and Warring States Period

A few years before 605 BC, Sun Shuao, the prime minister of Chu State, presided over the establishment of Yulou irrigation district in Huainan area, which mainly diverted water from the Shihe River for irrigation. It was the first large-scale irrigation canal system project built in the Spring and Autumn Period, and it was also an earlier large-scale water conservancy project recorded in the literature, two centuries before Dujiangyan Weir. The irrigation area adopts canal-pond series connection technology, which is, digging channels, building ponds, and connecting numerous ponds in series through channels, thus forming today's melon-on-the-vine irrigation project type. Among them, ponds are mainly used to regulate channel water, and the water in channels is accumulated in ponds in the non-irrigation season; the accumulated water is then used to irrigate farmland in periods of drought, thus improving the irrigation guarantee rate. The people of Chu State also built Quebei Pond, which irrigated thousands of hectares of farmland. During the Warring States Period, Changqu Channel and Muqu Channel were built in the Hanshui River Basin. The people of Chu State also invented some simple water lifting machines, such as shadufs, which were used to lift water for irrigation.

In the Spring and Autumn Period and the Warring States Period, early urban flood control and drainage projects began to appear. Jinan City, the capital of the Chu State, consists of drainage channels, drainage ditches, rivers in the city, a water gate on the city wall and moat. The flood and sewage in the city are gradually collected into the river channel and then discharged out of the city. During this period, there were canals leading to the Hanshui River and Yunmeng Lakes in the western part of Chu State, while in the eastern part Honggou Canal connected with the Yangtze River.

4.3. From the Qin and Han Dynasties to the Northern and Southern dynasties

In this period, as far as irrigation engineering is concerned, no matter whether the country was unified or split, most of the dynasties actively built water conservancy projects to ensure agricultural production, so that the irrigation projects along the Yangtze River and its tributaries such as the Ganjiang River, Hanjiang River, Xiangjiang River and Yuanjiang River were significantly developed.

In the late Western Han Dynasty, water conservancy was developed in Nanyang of Henan Province and Xiangyang of Hubei Province in the Han River Basin. At the beginning of the Eastern Han Dynasty, Du Shi, the prefect of Nanyang, Henan Province, continued to develop water conservancy in the Nanyang area, gradually making Nanyang a famous irrigation area in China. Du Shi also invented a hydraulic power blast furnace for smelting iron, thus providing iron farming tools for the development of local agriculture. After the end of the Eastern Han Dynasty, the northern region was constantly at war.

With the migration of nearly one million immigrants and a large amount of wealth to the south, a large number of water conservancy talents and technologies gathered here. After development, some areas in the middle reaches of the Yangtze River gradually became important grain bases in China, and their status and role in the whole country rose. During the Three Kingdoms Period, the Lishui River Basin was developed because of the cultivation of farmland.

In terms of flood control projects, in the Qin and Han Dynasties (221 BC–220AD), with the gradual increase and severity of flood disasters along the Yangtze River, people began to pay attention to building dikes for flood control and digging channels for drainage. During the Western Han Dynasty (202 BC–9 AD), Laolong Levee was built near Xiangyang in the middle reaches of the Hanjiang River. In the Eastern Han Dynasty, the original earth dike was rebuilt as a stone dike. Since then, the Jingjiang section of the Yangtze River and the middle and lower reaches of the Han River became the focus of flood control in dynasties past. During the reign of Emperor Yonghe of the Eastern Jin Dynasty (345–356), Huanwen guarded Jingzhou and ordered Chen Zun to build Jin Levee on the north bank of the Yangtze River, which is the beginning of the Jingjiang levee and the earliest record of the construction of the Yangtze River Levee. In the Northern and Southern Dynasties, there were also scattered dikes on the south bank of the Yangtze River. Since then, the construction of dikes has gradually developed along the lower reaches of the Yangtze River.

As far as shipping is concerned, in the Han Dynasty, shipping along the Yangtze River was very common. Along the Yangtze River and Xiangjiang River, one could reach the Pearl River Basin through Lingqu Canal, which was the waterway that Ma Yuan used to attack Lingnan area in the early Eastern Han Dynasty. Along the Yangtze River upstream, one can reach the areas of Bashu and Qinlong. During the Three Kingdoms Period, Wu State was located in the middle and lower reaches of the Yangtze River, with developed shipping and a strong water army.

In order to meet the needs of the Yangtze River water war, commercial transportation and maritime transportation, Wu State set up ship-building bases in Dongting Lake, Poyang Lake and Chaohu Lake areas to build various types of ships. During the Jin Dynasty, some canals were excavated, among which Yangxia Canal was the largest. In the Eastern Jin Dynasty, the economic development of Hubei Province was faster. Today’s Hankou City has become the place where the Yangtze and Hanjiang rivers meet and the place where agricultural products in Dongting Lake Basin must be transported to.

4.4. During the Sui, Tang and Song dynasties

After the Song Dynasty moved to the south, Hangzhou, Zhejiang Province was regarded as its capital. Provinces in the middle reaches of the Yangtze River were close to the capital and were the places where the main wealth of the country came from. Therefore, a large-scale reclamation was started here. There were many polder fields on the south bank of the Yangtze River, such as Xuanzhou, Wuhu and Dangtu in Anhui Province, and these were connected with each other. The dikes of polder fields separate farmland from external water and regulate the inflow and outflow of internal water and external water by an irrigation and drainage canal system and the operation of sluice gates on the dikes. If there is difficulty in gravity irrigation and drainage, water lifting machinery is supplemented. Waterways outside the polder fields have the benefits of irrigation, drainage and shipping. The polder fields on the north bank of the Yangtze River, such as Lujiang, Wuwei and Hefei, have gradually developed. At the beginning of the Southern Song Dynasty, Dongting Lake and Hanjiang Plain, located in the north and south of the Jingjiang River, the local government began to build dikes and weirs along the Yangtze River to cultivate land and recruit people for farming. Dikes and weirs were built in these watery areas to resist the floodwater coming in from other areas, for both irrigation and drainage, which actually became polder fields. They were the early polder fields in Jianghan area.

4.5. During the Yuan, Ming and Qing dynasties

From the Ming and Qing dynasties to 1949, polder fields along the Yangtze River developed from south to north, and there were a large number of polder fields in the north and south of the Yangtze River in Anhui Province. The polder fields to the south of the Yangtze River are most famous in Tongling, Nanling, Xuancheng, Wuhu and Dangtu, while the polder fields to the north of the Yangtze River are most famous in Huaining, Tongcheng, Wuwei, Hexian and Hefei. Large official dikes, such as Dangtu Polder, covered an area of 16,008 hectares, bordering Danyang and Shijiu Lakes in the east and Luxi Lake in the west. Its dikes were 106,920 metres long, with the famous Yongfeng Polder inside. After the development and management of the past dynasties, up to the Ming Dynasty, there were more stable and high-yield areas in the provinces of Hunan, Hubei, Jiangxi and Anhui, and the output of ordinary fields was 50 per cent higher than that in the Tang and Song Dynasties. The north and south areas of Dongting Lake became another developed agricultural area in the Yangtze River Basin. At that time, there was a saying that ‘If Hubei and Hunan provinces have a bumper harvest, the whole country will have enough food’.

During the Yuan, Ming and Qing Dynasties, due to the increasing reclamation along the lakeside and the Yangtze River, the diversion outlets of the Yangtze River were blocked. During the Jiajing period of the Ming Dynasty (1521–1566), the Jingjiang Levee formed a whole. In addition to the Jingjiang Levee, large-scale dikes were built in other sections and in many tributaries of the Yangtze River. Since the beginning of the Ming Dynasty, dikes have been built in Wuhan city, and revetments have been built along the Yangtze River and Hanjiang River in the city. In the late Ming Dynasty, the levee system was basically formed along the Yangtze River and Hanjiang River in Wuhan, which was further improved and reinforced in the Qing Dynasty, but its flood control standard was low. During the Ming and Qing Dynasties, the Huangguang Levee was built in Huangmei and Guangji counties in Hubei Province on the north bank of the Yangtze River, with a length of 87 kilometres; The Tongma Levee was built in Susong, Wangjiang and Huaining counties of Anhui Province, with a length of 175 kilometres; Wuwei levee, 125 kilometres long, was built in Wuwei and Hexian counties of Anhui Province. After the mid-Qing Dynasty, the levee system of the middle and lower reaches of the Yangtze River began to take shape.

In the Qing Dynasty, with the rapid growth of population, the Yangtze River Basin was developed on a large scale. People cultivated mountains in the upper reaches and blindly reclaimed lakes in the middle and lower reaches of the Yangtze River, resulting in increasingly serious floods and waterlogging, especially in the lower reaches of Jingjiang River and Hanjiang River. Therefore, the government attaches great importance to the governance of the Yangtze River. In the late Qing Dynasty, there were various discussions on the strategies for harnessing the Yangtze River, including opening diversion outlets, building and managing dikes, prohibiting the reclamation of mountains and the private construction of polders. Although there were many discussions, there was less implementation, and the effectiveness of governance was not great. In the tenth year of Xianfeng (1860), the south bank of Jingjiang River was washed out of the Ouchi River. In the ninth year of Tongzhi (1870), Songzi Dike broke apart and was washed into the Songzi River three years later, which led to the situation where the Jingjiang River diverted to Dongting Lake through four diversion outlets. The river-lake relationship between Jingjiang River and Dongting Lake became more complicated, which has had a far-reaching impact on the governance of the Yangtze River in modern times.

5. Threats to water heritage and protective measures

Firstly, the water heritage in the middle reaches of the Yangtze River is often affected by natural disasters such as floods, mountain torrents, etc. Some precious bridges, such as Rainbow Bridge in Wuyuan County, Jiangxi Province, a national key cultural relics protection unit, and Lecheng Bridge in Jingde County, Anhui Province, were washed away by the flood of the Yangtze River in July 2020; Some precious ancient buildings, such as Guanyin Pavilion in Ezhou City, Hubei Province, were also flooded and damaged to some extent. The Fengyu Bridge in Wangjiaping town, Zhangjiajie city, Hunan province, and Taiping Bridge in longnan county, Jiangxi Province were destroyed by mountain torrents.

Secondly, how to deal with the relationship between scientific protection and appropriate utilisation of the water conservancy project heritage which is still in use, is also a factor of whether the heritage will face the threat of destruction.

Thirdly, with the acceleration of economic and social development and the urbanisation process in the middle reaches of the Yangtze River, how to deal with the relationship between the regional economic and social development and heritage protection is also an important factor of whether the heritage will face the threat of destruction.

6. Legal protection in force

First, **national laws and regulations**. On the one hand, the water heritage in this region is mainly protected by *The Law on the Protection of Cultural Relics*; On the other hand, as a water conservancy project still in operation, it is mainly protected by *The Water Law*, *The Flood Control Law, The Regulations of the People's Republic of China on the Management of River Channels,* and *The Prevention of Water Pollution*, *The Law on Soil and Water Conservation*, *The Law on Land Administration*, and *The Law on Environmental Protection etc.*

Second, **local laws and regulations**. It mainly includes the cultural relics protection regulations or management measures of Hubei, Hunan, Jiangxi, Anhui and Henan provinces, such as the Administrative Measures for the Safety of Cultural Relics in Hubei Province (2017), the Regulations on the Protection of Cultural Relics in Hunan Province, the Administrative Measures for Cultural Relics Protection Units in Hunan Province (2008) and the Cultural Relics Protection Regulations of Jiangxi Province (2006); and the river management measures and lake management regulations of each province, such as Regulations on Water Conservancy Management of Dongting Lake Area in Hunan Province (issued in 2009 and revised in 2018), Regulations on Lake Protection of Jiangxi Province (2018), etc.

Third, **related planning and standardisation**. This mainly includes two aspects: the first is the overall plan for water system management, cultural relics protection, flood control, shipping and economic and social development of the Yangtze River, such as T*he Comprehensive Planning of the Yangtze River Basin, The Outline of the Yangtze River Economic Belt Development Plan (2016),* and *The Outline of the Yangtze River Delta Regional Integration Development Plan* (2019). The second is the planning and norms of water conservancy development and cultural relics protection in the provinces and counties along the Yangtze River, such as *The Development Plan of Cultural Undertakings in Hubei Province During the 13th Five Year Plan Period*, and *Regulatory Detailed Planning of New Towns Along the Yangtze River in Wuhan.*

7. Conservation and management of water heritages

The protection and management of water heritage in the middle reaches of the Yangtze River has the same characteristics as other places, that is to protect the heritage itself and its surrounding environment through various measures. At the same time, on the basis of comprehensive consideration of the value and preservation status of the heritage and the needs of the economic and social development of the region where it is located, the social and economic functions such as publicity, education, popularisation of science, research, leisure and tourism should be moderately expanded. For example, in the middle reaches of the Yangtze River, the Three Gorges Museum was built in Yichang city, and the Yangtze River Civilisation Museum was built in Wuhan, Hubei rovince, to carry out popular science and education on water conditions; Scenic tourist areas such as Ziquejie Terrace, Three Gorges Dam and Yueyang Tower have been built one after another. Some of them have leisure or entertainment functions, some have educational or popular science functions, and some have tourism functions, so that these precious heritages can be protected and passed down through proper utilisation.

As the protection of water heritage in the middle reaches of the Yangtze River is carried out along with the construction of water conservancy and hydropower projects such as the Three Gorges Project, Gezhouba Water Control Project and Danjiangkou Reservoir, it has the characteristics of protection and utilisation that other areas do not have, which mainly includes the following three aspects:

The first is the **investigation of hydrological inscription**. The investigation of historical flood and low water level in the Yangtze River began in the early 1950s, and there were as many as 10 large-scale investigations between Yibin and Datong in the main stream of the Yangtze River, among which three investigations in 1956, 1959 and 1966 were systematic and comprehensive, with more than 60 flood years and more than 2,800 flood marks. In the mid-1960s, by means of the combination of hydrology and archaeology, a large number of special investigations were carried out on cliff stone carvings related to historical floods, inscriptions related to ancient buildings, flood traces left on ancient building components, and sediment deposits caused by floods in ancient ruins strata, which are located on both banks of the main tributaries of the upper reaches of the Yangtze River. With the commencement of the Three Gorges Project, during 1994-1995, the hydrological inscriptions in the reservoir area were rechecked, photographed and measured again, and the historical flood and low water survey results were compiled and published.

The second is the **application of hydrological inscription**. Hydrological inscription has high scientific and applied value. When Gezhouba Water Control Project was designed, peak discharge in 1788 was selected as the design flood, and peak discharge in 1870 as its check flood. When the Three Gorges Water Control Project was designed, the peak and time-interval flood volume at Yichang since 1153 were calculated and added to the flood frequency calculation, thus solving the problem of the extension of the rare part of the flood frequency curve. The data all originate from hydrological inscriptions.

The third is the **protection of hydrological inscriptions.** They are mainly protected by moving them to other places, protecting the original site, retaining data and copying them in other places, etc. After the Three Gorges Project was impounded for 135 metres in 2003, most of the inscriptions along the Yangtze River were flooded. However, through different protection measures, these inscriptions were systematically protected and recorded scientifically. Among them, Sanyou Cave at the mouth of Xiling Gorge in Yichang preserves and displays the inscriptions left by literati since the Song Dynasty.

The fourth is **underwater archaeology**. This mainly involves the investigation, survey and excavation of ancient relics submerged in the Yangtze River, its tributaries and lakes, such as the investigation in Danjiangkou Reservoir in Hubei Province, Taiping Lake area and Xianghongdian Reservoir in Anhui Province, Hongmen Reservoir in Jiangxi Province from 2003.

8. Conclusion

The middle reaches of the Yangtze River are the most concentrated area of lakes in the whole basin. The lakes include Poyang Lake, the largest freshwater lake in China, Dongting Lake, the second largest freshwater lake, and Jianghan Lake Group, which is composed of large and small lakes. These lakes have the function of regulating and storing flood and irrigating farmland. Due to the uneven spatial and temporal distribution of precipitation, floods, waterlogging and droughts occur frequently in this area, especially in the upper reaches of the Yangtze River from July to August every year. The main stream of the middle reaches collects the water from the upper reaches and its tributaries, so the annual maximum water level often appears in this period. It can be said that the unique natural geography, climate, hydrology and water resources conditions in the middle reaches of the Yangtze River have produced a large number of water heritages with rich types, some of which have a remarkable uniqueness, such as the hydrological inscriptions of the Three Gorges, the flood control engineering system of Jingjiang Levee, the flood control engineering system of Shouxian and other cities, the drainage system of Ganzhou and other cities, the irrigation engineering system of melon-on-the-vine such as shaopi, and the Ziquejie Terrace, etc.

In recent years, the provinces in the middle reaches of the Yangtze River have attached great importance to the protection and utilisation of the water heritage and taken various measures to gradually protect the heritage itself and its surrounding environment. They have begun to explore various activities such as exhibitions, publicity, education, popularisation of science, research, landscape promotion, etc. relying on these heritages, so as to ensure that the heritage is properly used on the basis of protection. At the same time, for the unique hydrological inscription in the region, innovative hydrological archaeology and flood investigation were carried out; for the unique underwater sites and reservoir sites in the region; underwater archaeology has been creatively carried out. However, while some of the above-mentioned works have achieved certain results, some of them are still preliminary and need to be further strengthened.

In addition, in view of the damage to cultural heritage caused by mountain torrents, river floods and waterlogging in low-lying areas in recent years, further research and practice must be carried out on the mechanism of these water disasters on cultural heritage, flood monitoring and early warning and forecasting technology based on cultural heritage protection needs, as well as flood prevention engineering and non-engineering measures in cultural heritage areas.

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Case study: Dujiangyan Irrigation System

By Prof. Fei Tang and He Ting, Sichuan Province Institute of Cultural Relics and Archaeology, Chengdu, China

Located in the western Chengdu Plains of southwest China's Sichuan Province, the Dujiangyan Irrigation System is a large water conservancy project on the Minjiang River, which is a major tributary at the upper reaches of the Yangtze River. (Fig.1) The Dujiangyan Irrigation System began in the third century BCE, during the reign of King Zhaoxiang of the Qin State in the Warring States Period, and has implemented the comprehensive functions of water diverting, controlling, flood discharge, sediment draining, etc. for over 2,200 years. In *Science and Civilisation in China*, Joseph Needham wrote: '(It is) one of the greatest of Chinese engineering operations which, now 2,200 years old, is still in use and makes the deepest impression on all who visit it today…It can be compared only with the ancient works of the Nile.' In 2000, Dujiangyan Irrigation System was inscribed on the World Heritage List on the basis of cultural criteria (ii) and (iv):

'Criterion (ii): The Dujiangyan Irrigation System, begun in the second century BCE, is a major landmark in the development of water management and technology, and is still discharging its functions perfectly.

Criterion (iv): The immense advances in science and technology achieved in ancient China are graphically illustrated by the Dujiangyan Irrigation System.'

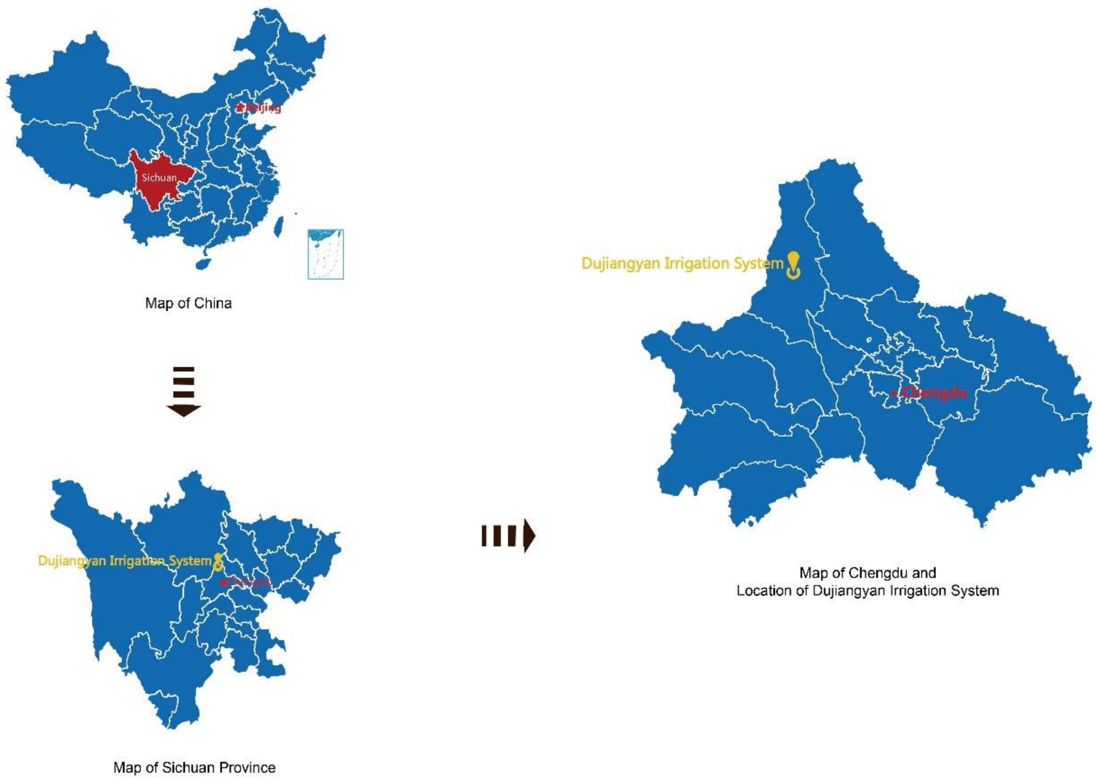

Fig. 1: Location of Dujiangyan Irrigation system. © *He Ting.*

As the great Western Han historian Sima Qian recorded in *Shih Chi* ('Historical Records'), the project was constructed under the supervision of Li Bing, the magistrate of Shu, and his son Li Erlang, both of whom are worshiped in the Erwang Temple to this day. It involved cutting the Lidui platform, digging canals, and irrigating neighbouring farmlands. In 141 BCE (Western Han Dynasty), the works were extended by magistrate Wen Weng. The renovation and extension of Dujiangyan Irrigation System continued throughout the Tang, Song, Yuan and Ming dynasties. To this day, it still functions perfectly in diverting water, discharging flood and sediment, and automatically regulating water supply, covering an irrigation area of over 660,000 hectares (Fig. 2). It is the oldest extant large water conservancy project worldwide, characterised by undammed water diversion, which results from the accumulation of the wisdom of an ancient labouring people.

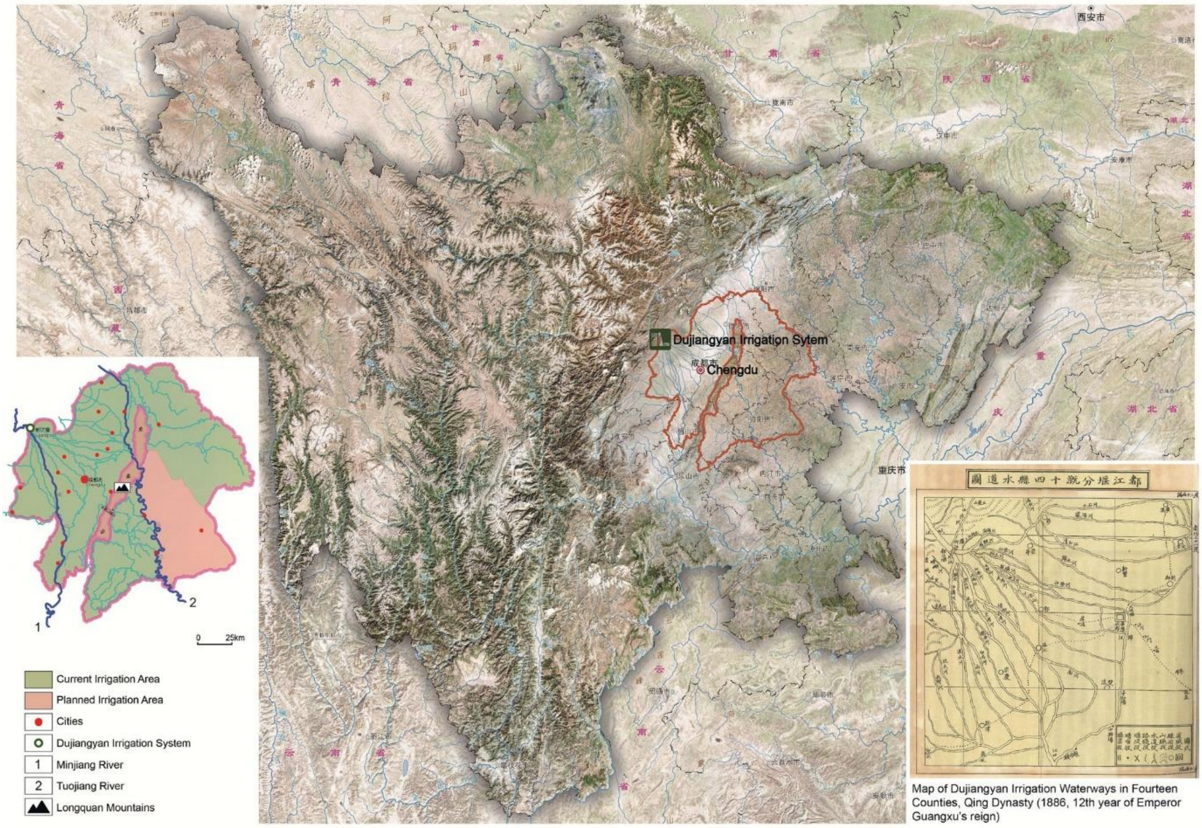

Fig. 2: Dujiangyan Irrigation Area. © *He Ting.*

The project mainly consists of two parts, namely the Weir Works and the irrigation area. Located at the junction of the Qinghai-Tibet Plateau and the Sichuan Basin, the Weir Works are at an altitude of 726 m, the highest point of the Chengdu Plains, and make great use of the topography to effectively control the water from the upper valley of the Minjiang River. The Weir Works include three key components: Yuzui Bypass Dike (Fig. 3), which makes full use of the bend to divert the surface water of Minjiang River into the Inner Canal flowing to the Chengdu Plains, while the deeper water with heavy silt concentration is directed into the Outer Canal; Feishayan Floodgate (Fig. 4), which transfers overflow, silt and pebbles from the Inner Canal to the Outer Canal in periods of heavy flooding; and Baopingkou Diversion Passage (Fig. 5), which was formed through cutting the Lidui Platform from the cliff in the third century BCE. Aided by ancillary facilities such as the Baizhang Dike, Erwang Temple Watercourse and V-shaped Dike Floodgate, the massive hydraulic works regulate the water supply in Chengdu Plains, support a population of about 20 million people today and keep the area free from drought and floods, creating a 'Land of Abundance'. (Fig. 6)

Fig. 3: Yuzui Bypass Dike. © *Xu Jun.*

Fig. 4: Feishayan Floodgate. © *Xu Jun.*

Fig. 5: Baopingkou and Lidui Platform. © *Xu Jun.*

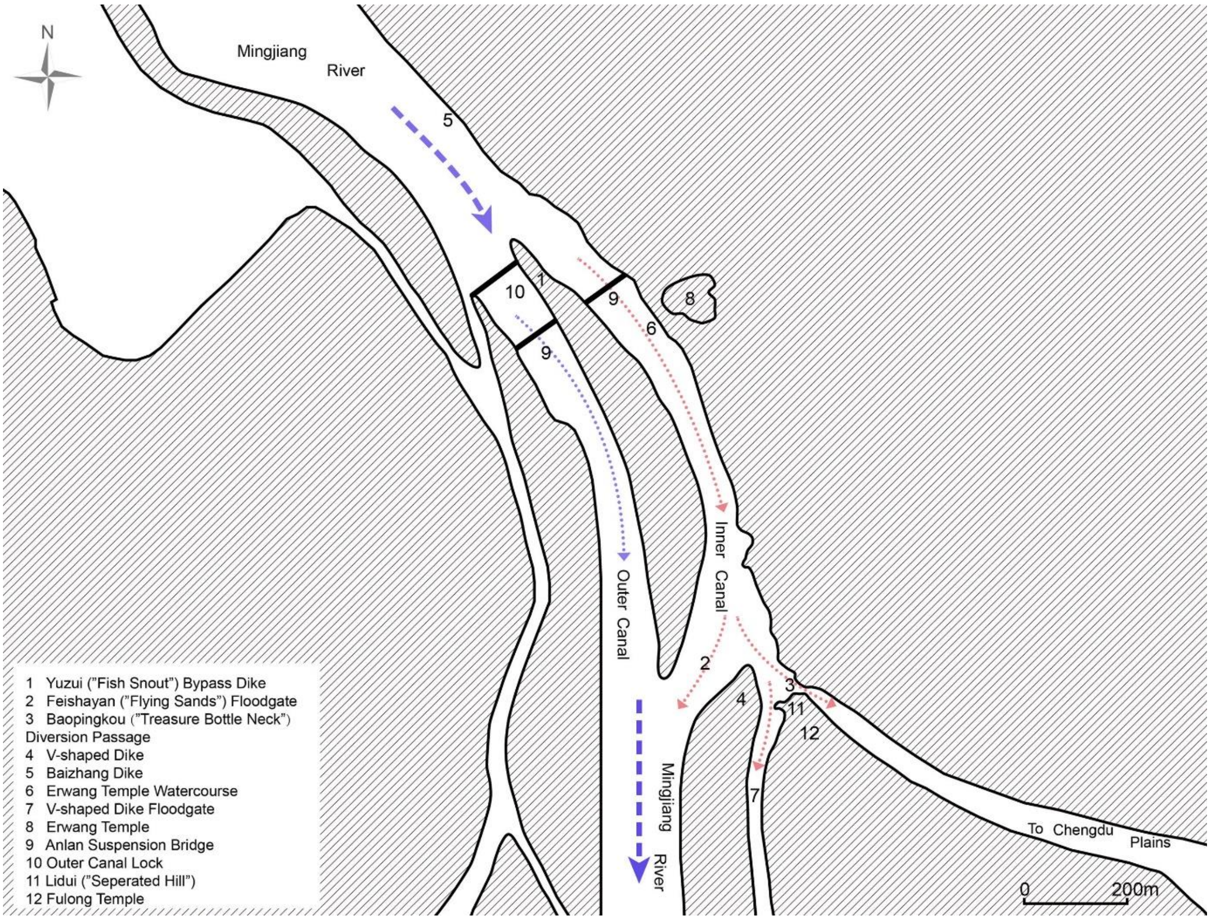

Fig. 6: Plan of Dujiangyan Irrigation System. © *He Ting.*

Dujiangyan Irrigation System is not only a 2,200-year-old engineering masterwork, but also a living heritage that has continued to function to the present day. Globally recognised guidelines and rules have been strictly complied with in the conservation and maintenance of the property in terms of location, design, materials, and techniques. All necessary attributes demonstrating the outstanding universal values of the property are included inside the property area and buffer zone. Comprehensive monitoring over the attributes as well as hydrological, geological, meteorological and environmental changes is carried out.

Dujiangyan Irrigation System had been preserved through centralised and specialised management throughout the past dynasties. Since the founding of the People's Republic of China, a special institution in charge of it has been established by the provincial authority. In 1982, it was declared a State Priority Protected Site by the State Council. It has also been listed among the first batch of National Scenic Areas and Historical Sites. The Dujiangyan Irrigation System is under the protection of national laws including the *Law of the People's Republic of China on Protection of Cultural Relics*, *Environmental Protection Law of the People's Republic of China*, and *Scenic Spots and Historical Sites Regulations*. On the provincial level, Sichuan Provincial Government has enacted the *Regulations on Conservation of World Heritages of Sichuan Province* and *Regulations on Management of Scenic Spots and Historical Sites of Sichuan Province*. In addition, *Overall Plan of the Mt. Qingcheng – Dujiangyan Scenic Area* has been implemented. Currently, the conservation condition of the property is excellent.

Located in the seismic zone of nearby Longmen Mountains, earthquakes pose potential risks to the conservation of the property. During the May 12th Earthquake in 2008, Dujiangyan Irrigation System was basically undamaged, but the ancient buildings including the Erwang Temple were severely damaged, but were successfully repaired afterwards. Additional negative factors affecting the property include decaying of wooden structures caused by the damp environment and termites, possible mudslides or landslides after heavy rainstorms and earthquakes, and weathering of stone cultural relics.

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07. China: Eastern coast

Case study: The peripheral water conservancy system in the archaeological ruins of Liangzhu City

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The Peripheral Water Conservancy System of Liangzhu Ancient City, discovered and confirmed in 2015, is an important part of the World Heritage site 'Archaeological Ruins of Liangzhu City'.

The Archaeological Ruins of Liangzhu City, inscribed on the World Heritage List in 2019 under criteria (iii) and (iv), are located in plains full of river networks on the eastern foothills of Tianmu Mountains in the Yangtze River Delta on the southeast coast of China, and is under the jurisdiction of Yuhang District, Hangzhou City, Zhejiang Province.

The archaeological Ruins of Liangzhu City (ca. 3300–2300 BCE) were the centre of power and belief of an early regional state with rice-cultivating agriculture as the economic support in the Circum-Taihu Lake Area of the lower reaches of the Yangtze River in the Late Neolithic era of China, offering unique evidence for the 5000-year history of Chinese civilisation.

The Peripheral Water Conservancy System is located at the middle of the foothills of the northern part of Liangzhu Ancient City, the farther northwest valleys, and the southwest isolated mounds. The system consists of three parts: Area of High-dam at the Mouth of the Valley, Area of Low-dam on the Plain, and Area of Causeway in Front of the Mountain. (Fig. 1)

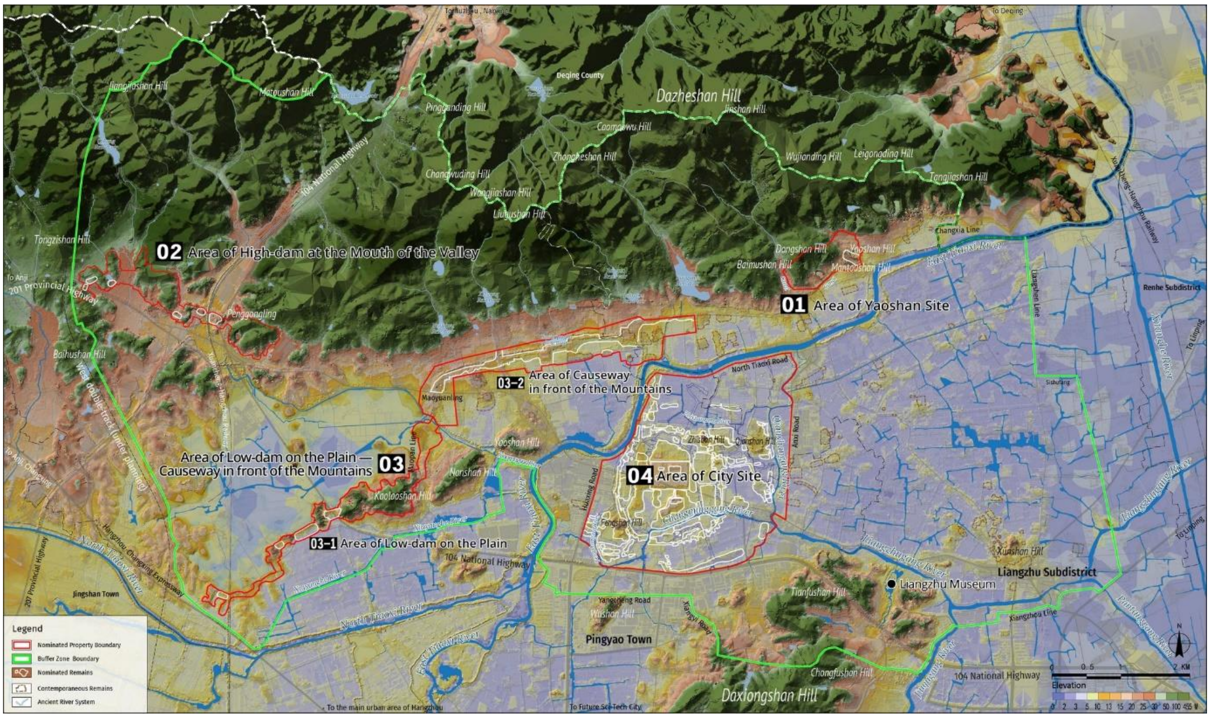

Fig. 1: Topographic and geomorphic map of the Archaeological Ruins of Liangzhu City. © *Institute of Architectural History, China Architecture Design & Research Group).*

Area of High-dam at the Mouth of the Valley is situated about 11 kilometres northwest of Liangzhu

Ancient City, extending east to west in the mountain between two mouths of the valley. Six dam sites have been discovered, spread about 2.3 km from east to west, which can be divided into two groups — east group and west group. The east group includes the Ganggongling Site, Laohuling Site, Zhoujiban Site, etc.; and the west group includes Qiuwu Site, Shiwu Site, Mifenglong Site, etc. (Fig. 2). The total area of the Area of High-dam at the Mouth of the Valley is about 7.6 hectares. The extant maximum length of each dam varies from 100 to 200 metres, and the maximum width varies from 60 to 160 metres. The cross section is slightly trapezoidal. The extant relative height of each dam is about 1.4–15 metres, and the extant elevation is about 25–40 metres above sea level.

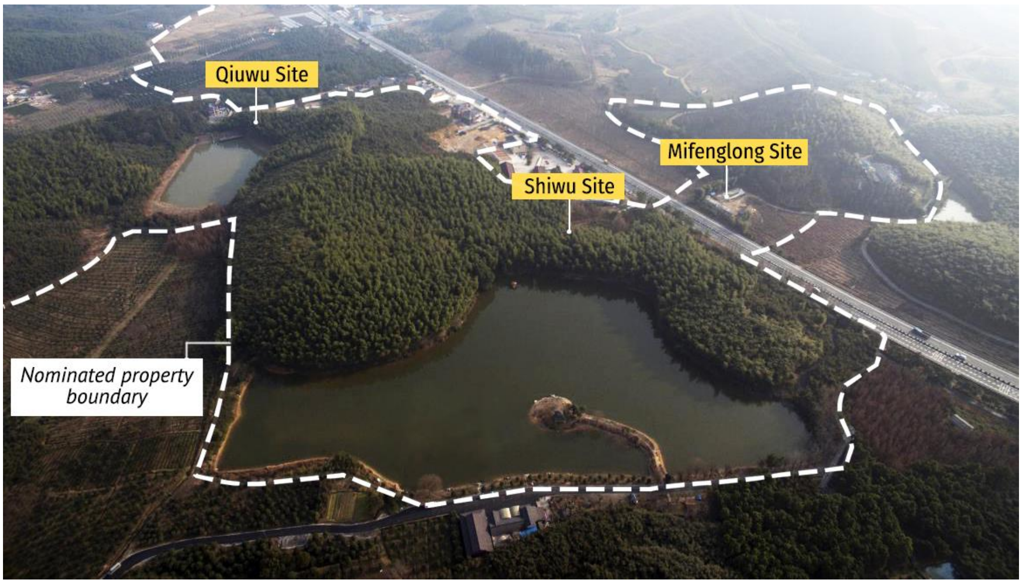

Fig. 2: Aerial view of the west group of High-dam at the Mouth of the valley. © *Zhejiang Provincial Institute of Cultural Relics and Archaeology.*

Area of Low-dam on the Plain is situated among the isolated mounds in the plain about 3.5 km to the south of Area of High-dam at the Mouth of the Valley. So far, four dam sites have been discovered, and these spread about 2.4 km from east to west. These dams, including Wutongnong Site, Guanshan Site, Liyushan Site, Shizishan Site, etc., have connected the continuous isolated mounds to the west of Kaolaoshan Hill. The length of each dam varies according to the distance of the isolated mounds. The extant maximum length ranges from 140 to 400 metres, and the extant maximum width ranges from 80 to 140 metres. The cross section is slightly trapezoidal. The extant relative height of each dam is about 6 metres, and the extant elevation is about 10 metres. The area of Area of Low-dam on the Plain is about 11.12 hectares.

Area of Causeway in Front of the Mountain is situated in front of Dazheshan Hill, a hill about 2 kilometres to the north of Liangzhu Ancient City. Its overall direction is an east-west curve, with an extant total length of about 5 kilometres and a width of 20–50 metres. The cross section of the dam body is roughly trapezoidal. The extant relative height of the dam is 2–7 metres, and the extant elevation is about 12-20 metres above sea level. The site covers an area of 63.84 hectares, which is the largest single remain in the Peripheral Water Conservancy System in the Archaeological Ruins of Liangzhu City. The remains can be divided into three sections from east to west. The east section is in a single dam structure, which is close to a straight line. Its length is about 1 km from east to west. There is a watershed extending southward from Dazheshan Hill on its west. To the west of the watershed is the middle section. It is a double structure consisting of a south dam and a north dam, which stretches about 2 km from east to west. The north dam can be divided into many parts forming a trisquare shape, and its west end extends northward and connects the mountains. The south dam and the north dam are parallel and change direction simultaneously. A distance of about 20–30 m separates the two dams and many water tanks formed in between. To the west of these two dams is the west section. It also takes a trisquare shape. The west section connects with the south dam and eventually turns southward to Maoyuanling, beyond where the west section turns into natural down land and joins the east section of Area of Low-dam on the Plain, which is a natural dam.

Each part of the dam in the Peripheral Water Conservancy System is different in structure and technique. The methods of constructing dam foundations include anti-seepage trench replacement, paving of grass-wrapped silt and green silt, and bedding stones at the bottom, etc. As for the dam body, it was basically constructed through stacking green silt or yellow clay, wrapped with yellow clay. Stacked grass-wrapped silt was also used at some key positions of the dam body so as to strengthen the dams. (Fig. 3)

Fig. 3: Grass-wrapped silt structure and details of Laohuling Site. © *Institute of Architectural History, China Architecture Design & Research Group.*

The construction of large-scale water conservancy projects pre-dated that of Liangzhu City, which points to the unprecedented social organisation ability and governing power of Liangzhu society. As a water resource management project of Liangzhu Ancient City, the Peripheral Water Conservancy System may have multi-functions including flood control, water storage, irrigation and water transport. This not only shows the scale and construction technologies of early water resource management projects of humanity, but also reveals the significant indivisible connection between water resource management and urban civilisation as well as the connection between water resource management and early states in the history of human civilisation. The scientific levels in the aspects of site selection, functional design and construction techniques of the project were rare in the world at that time, which fully demonstrate the creativity and scientific nature of the ancestors of Liangzhu in the aspect of man–land relationship, and it is an outstanding example of the development and utilisation of wetlands by early humans in East Asia.

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08. China: The Grand Canal

Regional overview: The Grand Canal of China

By Michel J. Cotte, Emeritus Professor of the University of Nantes, ICOMOS Advisor

The Grand Canal of China is already on the World Heritage List, the list from the 2014 WH Committee in Doha.[9] It offers a range of water management and use situations over around two millennium of history, narrowly linked with the history of China and of its successive dynasties. It worked as a pivotal skeleton of the Empire for centuries both for economy and social exchanges, as well as for administrative and military goals.[10]

1. General characteristics

Fig. 1: The general settlement of the Grand Canal in China. © *The Grand Canal, World Heritage nomination dossier.*

The Grand Canal forms a vast inland waterway system in the north-eastern and central-eastern plains of China, running from the capital Beijing in the north to Zhejiang province in the south. Constructed in sections from the fifth century BC onwards, it was conceived as a unified means of communication for the Empire for the first time in the seventh century AD (Sui dynasty). This led to a series of gigantic worksites, creating the world's largest and most extensive engineering project ensemble prior to the Industrial

[9] http://whc.unesco.org/fr/list/1443
[10] This article is mainly issued from the ICOMOS evaluation report for the World Heritage Committee in Doha (2014).

Revolution. It formed the backbone of the Empire's inland communications system and enabled the supply of rice to feed the population and the transport of strategic raw materials. By the thirteenth century, it provided a unified inland navigation network consisting of more than 2,000 km of artificial waterways, linking five of the most important river basins in China. Still a major means of internal communication today, it has played an important role in ensuring the economic prosperity and stability of China over the ages.

1.1. General climatic data

The Grand Canal connects the temperate regions of the north, with low or relatively low rainfall, and the subtropical regions further south, with a hot, wet climate that is particularly favourable for rice-growing. Furthermore, rainfall is seasonal, both in the north and south, with monsoons that represent major risks of flooding, giving rise to specific constraints for the construction of hydraulic facilities and the management of water resources.

1.2. Geographical implementation: a gigantic inland waterway system

The Grand Canal is located in the vast plains of north-eastern and central-eastern China. It runs from the present-day capital Beijing, in the north, to the province of Zhejiang, in the south, as far as the port of Ningbo, on the East China Sea. It connects five of the largest river basins in China: the Hai coastal river in the north which flows into the Bohai Gulf at Tianjin; the Yellow River which today runs to the north of Shandong, but which had southerly courses earlier in its history, until 1855; the Huai River whose lower course merged with the southern arm of the Yellow River; the Yangtze further south; and finally the Qiantang coastal river. The rivers generally flow from the mountainous west to the Yellow Sea and the East China Sea to the east. The Grand Canal system tends to connect them along a north-south axis, and it flows successively through five major natural regions: the great plain of north-eastern China and the downstream basin of the Yellow River; the low hilly zone of Shandong; the Yangtze delta with its numerous lakes; the coastal plain of Ningbo – Shaoxing; and the Qiantang estuary region.

1.3. Heritage main characteristics

In the thirteenth century, it provided a complete inland network of more than 2,000 km of navigable man-made waterways. The nominated property aims to present the most comprehensive sample possible of the range of vestiges of the historical facilities of the Grand Canal, over the whole of its course. The remains are either archaeological or constitute a hydraulic heritage which is in many cases still functioning.

2. Main sites of the cultural heritage of water management

The Grand Canal has 10 main sections of ancient artificial waterways. The historic names have been preserved, and the canals are presented in chronological order according to which were completed first. The nominated serial property is made up of 31 individual properties, corresponding to a little over 1,000 km of navigable waterways, most of which are still filled with water, but some of which are today archaeological sites. Together they represent a total of 85 major heritage items, consisting of 27 canal sections and 58 cultural heritage sites on the Grand Canal. The chosen properties illustrate archaeological sites showing its course, river navigation landscapes, technical facilities used for water management, urban landscapes associated with the canals, and monuments.

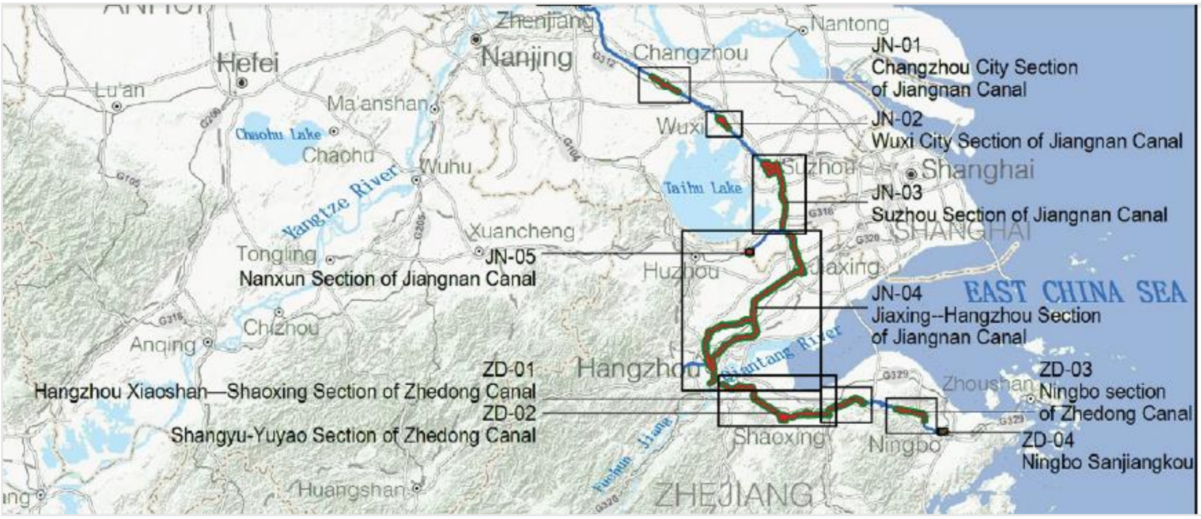

Fig. 2: Southern part of the Grand Canal's heritage: Zhedong (ZD) and Jiangnan (JN) sections. © *The Grand Canal, World Heritage nomination dossier.*

2.1. Zhedong Canal (Province of Zhejiang)

It mainly contains the following components registered as having World Heritage significances related to the water system management of the Grand Canal. The description is made from south to north of each canal section:

- *Ningbo Sanjiangkou* (ZD 04) is an urban river site at the confluence of the Yao and Fenghua Rivers, in the town of Ningbo which marks the end of the Grand Canal.
- *Ningbo* (ZD 03) is a section of canal (23 km) which runs to the town of Ningbo; this section is lateral to the Yao River, of which it forms a second artificial branch in order to avoid tidal currents.


Figs. 3–4: Zedong canal: the Bazi Bridge and the canal banks in Hangzhou. © *The Grand Canal, World Heritage nomination dossier.*

- *Shangyu-Yuyao* (ZD 02) is a section of canal (25 km), which runs from the River Cao'e, in the town of Shangyu, for some 20 kilometres to the east and the River Yao; it bears witness to the economic role of the canal and the prosperity it generated.

- *Hangzhou Xiaoshan-Shaoxing* (ZD 01) is the start of the Zhedong Canal at the point where it links up to the Qiantang River, which it connects to the urban areas of Shushan, Shaoxing and Shangyu. It comprises: (1) the section of canal between these towns (90 km); (2) the docks of the distribution centre of Xixing; (3) Bazi Bridge; (4) the urban zone of the Bazi Bridge; (5) a portion of the former towpath.

2.2. Jiangnan Canal (Zhejiang and Jiangsu)

It comprises the following heritage sections and sites, from south to north:

- The *Jiaxing-Hangzhou Section* (JN 04) comprises: (1) a long section of the canal with numerous branches (187 km), between Taihu Lake in the north and Qiantang River in the south, with navigation landscapes; (2) the archaeological site of Chang'an, bearing testimony to an eleventh-century three-gate lock, to which was added a boat passage with a winch-towing system in the fourteenth century; (3) the site of the Fengshan hydraulic gate, (4) the Fuyi granary at Hangzhou; (5) Changhong Bridge; (6); Gongchen Bridge; (7) Guangji Bridge, (8) the Qiaoxi conservation area at Hangzhou. This part of the canal bears witness to a diversified network of waterways associated with rivers and lakes.

- *Nanxun* (JN 05) is a district of the canal which comprises: (1) an urban branch of the Jiangnan (or Ditang) Canal (2 km); (2) the urban area of Nanxum. This is a particularly well-preserved urban section, and is typical of the canal, representing the prosperity it brought to the waterside populations.

- *Suzhou* (JN 03) comprises (1) a section of the canal in the marshes and then in the city, along with numerous urban branches (73 km); (2) Pan Gate on one of the branches of the canal; (3) Baodai Bridge; (4) the Shantang canal conservation zone; (5) the Pingjiang quarter, (6) the former Wujiang towpath. Just next to the Yangtze, Suzhou was from time immemorial a major regional economic and cultural capital; it bears witness to the most intense and most continuous use of the southern canal system, from the sixth century BC to the present day.

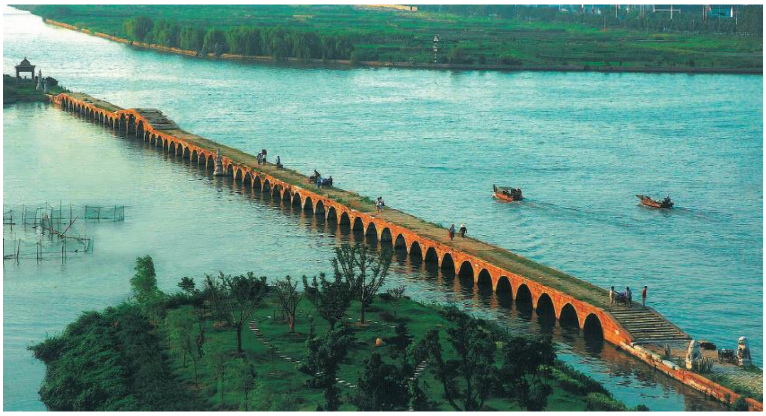

Fig. 5: Suzhou: Baodai Bridge. © *The Grand Canal, World Heritage nomination dossier.*

- *Wuxi City* (JN 02) comprises (1) an urban section of the historic canal of Jiangnan (14 km), with two branches that encircled the former urban centre, (2) the historic Qingming bridge quarter.

- The *Changzhou City* (JN 01) section comprises a 23-km section of the canal which passes through the built-up area; it illustrates a typical landscape of the canal in the setting of a large city.

Fig. 6: Grand Canal crossing the modern city of Changzhou. © *The Grand Canal, World Heritage nomination dossier.*

2.3. Huaiyang Canal (Jiangsu)

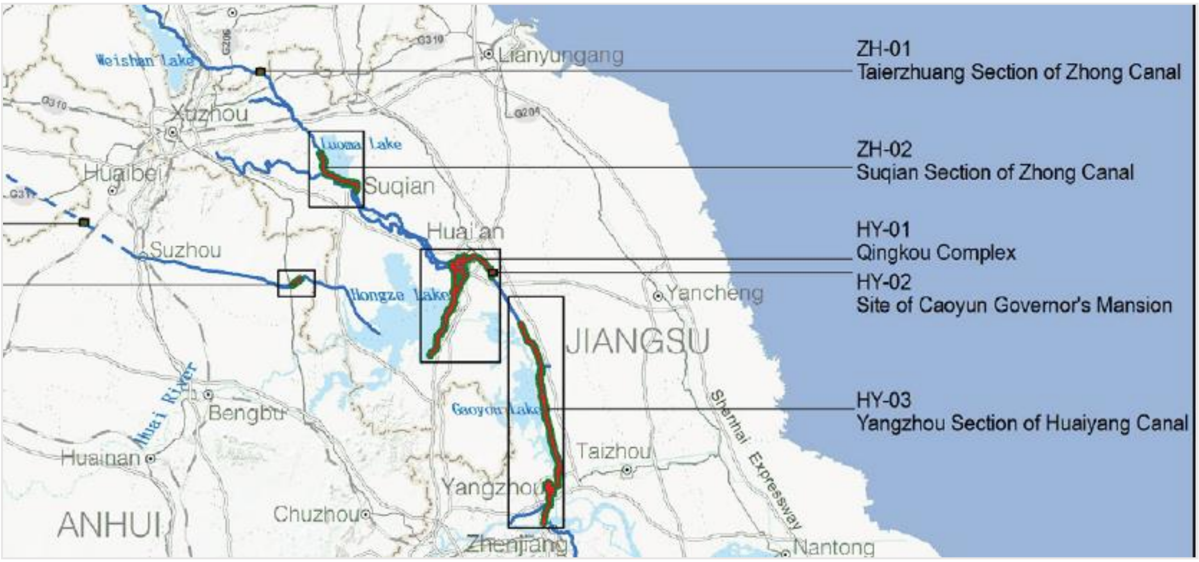

Fig. 7: Central south-eastern part of the Grand Canal: Huaiyang or Li Canal section (HY) and Zhong (ZH) section. © *The Grand Canal, World Heritage nomination dossier.*

- The *Yangzhou Region* (HY 03) comprises (1) a very long section of canal (134 km) and its branches in the town of Yangzhou; it illustrates a navigation landscape and an urban canal landscape; (2) the archaeological site of the drainage lock of Luibao; (3) the Yucheng post, (4) the remains of the ancient Shaobo dike; (5) Shaobo docks; (6) Slender West lake, (7) Tianning palace and temple, (8) Ge garden, (9) Wang Lumen's residence; (10) the Salt Ancestral Temple; and (11) Lu Shaoxu's residence. This is one of the sections of the Grand Canal that has been in use for the longest period, demonstrating the hydrological changes that have occurred over the ages, and the gradual transition in navigation from lakes and natural rivers to an entirely artificial waterway; Yangzhou reflects the economic history of the canal, and was at the heart of the lucrative salt trade, and bears witness to the resulting urban and cultural wealth.

- The archaeological site of the *Caoyun Governor's Mansion* (HY 02) is close to the canal, in the former provincial capital Huai'an; it is the most important vestige of the Caoyun imperial administration.

Fig. 8: Archaeological site of the Caoyun Governor's Mansion. © *The Grand Canal, World Heritage nomination dossier.*

- The *Qingkou Site* (HY 01) near Huai'an consists of (1) a long section of the ancient canal (46 km) illustrating a canal landscape, (2) the archaeological remains of the Qingkou hydraulic complex designed to cross the former bed of the Yellow River and the junction with the Huai River, (3) the boat lock of Shuangjin, (4) the boat lock of Qingjiang, (5) the stone dike of Lake Hongze. Benefiting from a water supply either from the Huai River or from the earlier course of the Yellow River, depending on the period, and the lake as a spillway, the Qingkou site is a vital nodal point of the Grand Canal and its history. It was completed in the sixteenth century and operated for around 200 years in its most elaborate form. It is one of the most emblematic sites in terms of the techniques and scientific knowledge embodied in the Grand Canal.

Fig. 9: Qingkou – Hongze Lake and dike. © *The Grand Canal, World Heritage nomination dossier.*

2.4. Zhong Canal (Jiangsu and Shandong)

- *Suqian* (ZH 02) is a canal section (35 km) which includes (1) its course in the Sucheng district and on the edge of the Luoma Lake, (2) the location and the remains of the temporary palace and the Royal Dragon Temple. It is a canal landscape which bears witness to the ultimate efforts made to overcome and break free from the natural constraints affecting the river navigation of the Yellow River. This principle of independence reaches a higher degree here than at any point on the Grand Canal.

- *Taierzhuang* (ZH 01) is a former section of canal (3 km) in an urban zone, today replaced by the Hanshuang canal a little further south.

Fig. 10: Zhong canal. © *The Grand Canal, World Heritage nomination dossier.*

2.5. Tongji Canal (Henan and Anhui)

- *Si* (TJ-07) comprises an annex section of the canal (6 km), which connected the town of Sicheng to the Xinsui River; this is a section that is still filled with water, and still has its rammed-earth revetments. It is an archaeological site.

- *Liuzi* (TJ-06) consists of (1) a canal section (2 km) and (2) a bridge site; both are archaeological; they illustrate the canal facilities, which demonstrate great architectural quality in the use of stone, and the remains of boats, which confirm the scale of river traffic between the seventh and eleventh centuries.

- *Shangqiu Xiayi* (TJ-05) forms another archaeological section of the canal (0.5 km) in the town of Jiyang; it also bears witness to the exceptional dimensions of the Tongji Canal, the shape of the dikes, and navigation practices.

- *Shangqiu Nanguan* (TJ-04) is an archaeological section of the Tongji Canal (1 km) which illustrates the construction techniques of the canal and the use of rammed-earth revetments during the Tang and Song Dynasties; it also bears witness to the great size of this canal, designed in the seventh century.

- *Zhengzhou* (TJ-03) is one of the few typical sections of the Tongji canal (20 km) still in use, close to the Yellow River; there is also an archaeological part (a reach providing a connection to the river and a water supply).

- *Huiluo* (TJ-02) is the archaeological site of one of the largest granaries on the Grand Canal; it is a suburban site north-east of the present-day town of Luoyang; its vast scale illustrates the extensive range and power of the imperial Caoyun system.

- *Hanjia* (TJ-01) is the archaeological site of an imperial granary, where the canal reaches the former capital Luoyang; it illustrates the principle of large-scale commercial interchanges for the benefit of the capital, and their control by the Caoyun imperial administration.

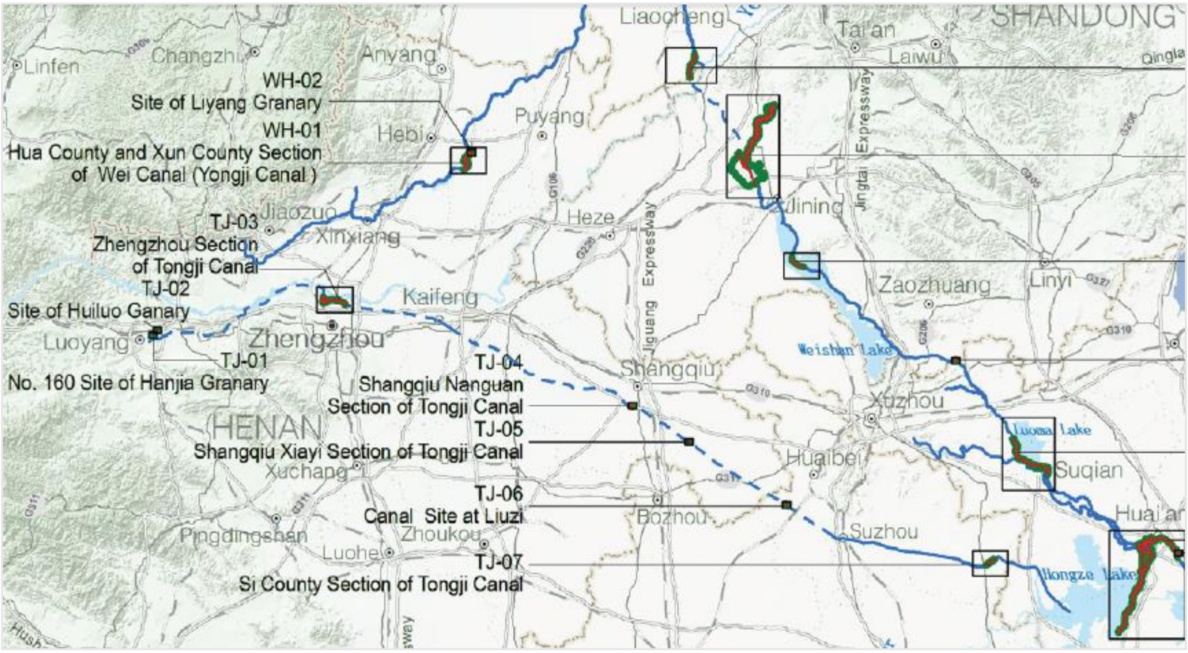

Fig. 11: Central-western part of the Grand Canal: Tongji (TJ) and Wei or Yongji (WH) sections. © *The Grand Canal, World Heritage nomination dossier.*

Fig. 12: Tongji Canal is an archaeological heritage in Luizi, but the bridge and canal banks are still functional. © *The Grand Canal, World Heritage nomination dossier.*

2.6. Wei Canal (Henan)

- *Hua and Xun* (WH-01) comprise a relatively long section of the Wei Canal (18 km); this is the best-preserved section, and forms one of the most typical landscapes illustrating ancient navigation in the inland regions.

- *Liyang (WH-02)* is the archaeological site of a large granary dating from the Sui Dynasty; it is situated in the town of Xun, close to the Yellow River, and bears witness to the changes in form of silos and warehouses from the Sui to the Song Dynasty.

Fig. 13: Archaeological site of a large granary related to the Grand Canal commercial function, Wei Canal. © *The Grand Canal, World Heritage nomination dossier.*

2.7. Huitong Canal (Shandong)

Fig. 14: Nanwang, the Daicun dam. © *The Grand Canal, World Heritage nomination dossier.*

- *Weishan* (HT-04) is a section of canal (9 km) which includes: (1) the archaeological site of the ancient canal as it crossed Dushan Lake; (2) the remains of the Lijian lock. This site has unique landscape importance, and also bears witness to the efforts made by man to overcome the caprices of nature and changes in rivers and lakes over the course of history.

- The *Nanwang* Complex (HT-03) includes: (1) a section of the Huitong Canal comprising archaeological remains at the confluence with (2) which is the whole of the supply reach for the Xiaowen canal, from the Daqing River (102 km), which is also a navigable branch; (3) the Daicun Dam which is the river water intake for Xiaowen; (4) the remains of the Shili lock; (5) the archaeological site of Xujiankou lock; (6) the archaeological site of Xingtong; (7) the archaeological remains of a brick dike; (8) the Liulin lock; (9) the archaeological site of the Royal Dragon Temple at the confluence, together with the remains of an overflow weir; (10) the site of the Siqiuanpu lock. This component bears testimony to many kinds of technical know-how, in a context that was crucial for the operation of the canal as a whole.

- The *Yanggu* (HT-02) complex includes: (1) a section of the canal (19 km) at the approach to its confluence with the Yellow River; (2) the lower lock of Echeng; (3) the upper lock of Echeng; (4) the lower lock of Jingmen; (5) the upper lock of Jingmen. This site is emblematic of the hydraulic techniques used in Chinese canals during the Qing Dynasty.

Fig. 15: Central North-Eastern part of Grand Canal: Huitong and Nan sections. © *The Grand Canal, World Heritage nomination dossier.*

- The town of *Linqing* (HT-01) marks the historic intersection between the waterways running to the west and the former capitals, to the north and Tianjin, and to Shandong and the south. The property includes: (1) the two branches of the Huitong Canal at its confluence with the Wei Canal, and their combined flow to the south (8 km); (2) the Linqing customs post. This was an important place for the control and organisation of river traffic.

Fig. 16: Archaeological dike of the canal made of bricks. © *The Grand Canal, World Heritage nomination dossier.*

2.8. Nan Canal (Hebei and Shandong):

Cangzhou–Dezhou (NY-01) is a section of the Nan Canal which includes: (1) the canal section in the town of Decheng Qu and the surrounding region, mainly to the north (94 km); (2) the Xiejia Dam at Lianzhen; (3) the well-preserved rammed-earth levée of Huajiakou, built under the Qing Dynasty. The site is also an example of the technique of using curving branches with gates, which function as locks.

2.9. Bei Canal (Tianjin)

Sanchakou (BY-01) is a section of the canal comprising the eastern part of the Bei Canal, the arrival of the Nan Canal at Tianjin and their urban junction (71 km). The Bei Canal has a winding course. After connecting with several rivers, it forms an urban waterway which continues to the sea via the Haihe Estuary. An intermodal point between river and sea traffic, the site constitutes an urban landscape that is typical for canals in the northern provinces of China.

Fig. 17: Northern part of Grand Canal: Bei (BY) and Tonghui (TH) sections.
© *The Grand Canal, World Heritage nomination dossier.*

Fig. 18: The junction of Grand Canal and Tianjin River. © *The Grand Canal, World Heritage nomination dossier.*

2.10. Tonghui Canal (Beijing)

- *Old Beijing City* (TH-01) comprises: (1) an urban section of the canal (0.5 km), which is an archaeological site; (2) the upper lock of Chengqing; (3) the lower lock of Chengqing; (4) Shixha Lake. Beijing marks the northern end of the Grand Canal, and also shows how canal planning affected the layout and drainage of the old city.

- *Tongzhou* (TH-02) is a section of the canal (5 km) where it joins the Wenyu River and where the Bei Canal exits in the direction of Tianjin. This was a key node for the control of traffic at the entrance to the capital for the Caoyun system, during the Ming and Qing Dynasties.

3. Threats to water heritage and monitoring

3.1. Summary of threats at the time of evaluation as WH property (2014)

The Grand Canal passes through provinces which have always been amongst the richest in China, throughout its history. The strong economic development since the 1990s has necessarily had an impact on the canal environment in many places: bridges, motorways, modern facilities for the canal itself (locks, port zones, dockyards, etc.), industrial zones often linked to the canal, urban expansion zones, etc.

Pressure from tourism is felt in several specific zones of the Grand Canal: (1) hydraulic complexes developed as parks, such as Nanwang and Quingkou, (2) lake and canal zones which are sought after for leisure purposes and for urban development, (3) major historic urban centres which are already well-known tourist destinations. The State Party considers that such pressures are relatively moderate, and that current facilities are sufficient to cope with them.

Bearing in mind the scale of urban development and population growth along the Grand Canal, the current environmental conditions are not considered to be excessively poor by the State Party. They are in line with the nationally recommended standards. The main environmental factor affecting the property is constant pressure on water quality, as the canal and its associated hydrological elements constitute a water reserve and are often used as an outfall for wastewater after treatment, of varying intensity depending on the location). The canal is affected, like all highly urbanised regions, (but less directly because of the water), by the quality of the air, which is impacted by industrial activity, the boom in individual means of transport, and rapid urban development.

With regard to natural risks, the Grand Canal is directly threatened by flooding risks as a result of meteorological conditions (rainfall, storms and occasional hurricanes). Up to a certain limit, the canal plays an important role in the regulation of water levels and the prevention of flooding risks. Other natural disaster risks also exist, but at much lower levels of probability. The risk of fire in urban settings is the most significant risk, given that a great deal of wood is used in many buildings.

The impact of climate change may increase the existing imbalances in rainfall between the provinces, and thus directly affect water resources, both as regards the canal and the life of local residents. The dry periods in the Northern provinces may become longer and more intense; the monsoon episodes may become more violent and longer in the subtropical provinces.

At the time of evaluation (2014), ICOMOS considers that the main threats to the property are economic and urban development, together with the risk of flooding. Here and there, the risk of fire in a historic urban setting should be taken into account. Pressure from the development of tourism could become a bigger phenomenon than predicted over the coming years, at least in certain zones of the Grand Canal.

3.2. Monitoring

A large amount of material already exists about the monitoring of the property, in terms of its hydraulic operation, the various urban preservation policies, and the active policy recently introduced for the conservation and valorisation of the property. The material consists of reports and studies on conservation, some of which were drawn up for the preparation of the nomination file. Archiving of technical information about the management of the canals is currently being carried out at both local and national level. In 2012, there were 21 recent monitoring reports on individual sites, 8 water quality monitoring reports, 16 major conservation-restoration project reports for components of the property, and 21 reports on local monitoring or district monitoring of hydraulic management.

In view of the diversity of issues and situations encountered, the following general categories are proposed:

- *Physical fabrics*:
  - Current condition of the individual components (shape, structure, materials, etc.)
  - Uses
  - Relationships between the elements themselves and with the environment

- *Factors affecting conservation efforts*:
  - Natural environment (weather, geology, environment, ecology, etc.)
  - Social environment (urban development, economic installations, pollution, etc.)

- *Conservation and management:*
  - Tourism (number of tourists, financial and economic impacts)
  - Intervention practices (archaeological excavations, routine maintenance, environmental improvement, conservation projects, etc.)
  - Heritage enhancement (exhibitions, interpretation centres, tourist facilities, etc.)
  - Management and staff resources (implementation of management plan, management bodies, management staff, funding, etc.)

- *Security:*
  - General security and fire security
  - Measures to deal with emergencies and unexpected incidents

The State Party intends to ensure that the monitoring of the property is carried out using standardised practices under the Master Plan and the Property Management Plan. The practices will be coordinated between the various levels (national, provincial and local). To set up the necessary system for monitoring and sharing information between all the bodies involved, the State Party is currently setting up a Grand Canal Heritage Monitoring and Archive Centre, with its own staffing and with local centres at the property's sites. A guide for Grand Canal monitoring and archives has been published to harmonise practices. Although the setting up of the centre seemed to be a project when the nomination file was drawn up (at the end of 2012), the additional documentation supplied by the State Party (October 2013 and February 2014) refers to the setting up of 41 local and regional agencies. However, the definitive setting up of the centre was not scheduled until 2015.

At the time of evaluation (2014), ICOMOS considers that the monitoring of a complex property such as the Grand Canal must be set up in a permanent and coherent form that covers all the components. This work has begun, but it is now necessary to complete its implementation.

4. Legal protection in force

Specific priority protection and conservation measures apply to those properties already inscribed on the World Heritage List and those inscribed on the Tentative List of China, in accordance with the *Law on the Protection of Cultural Remains*. This measure has been fully applicable since 2008. Meanwhile, the list of the six key examples of the cultural heritage of China has been promulgated, and includes 18 sections and 49 elements of the Grand Canal. This recognition by the Council of State gives these sites priority in protection terms. As indicated in the additional documentation of February 2014, all the properties nominated for inclusion on the World Heritage List were granted this maximum level of protection by the State Party in 2013.

4.1. State-level protections

The serial property is managed in accordance with national regulation laws which are applicable for a variety of reasons. The law is applied through administrative regulation texts which apply to all the properties concerned, and by provincial or local protection plans for specific properties. The property as a whole has been the subject of the promulgation of 54 texts of this type.

Examples:

- *Law on the administration of the regulation of rivers* (including canals) (1988), amended by the *Law on flood control,* the *Law on water* and the *Law on water pollution*;
- *The national law on the regulation of the protection of historic towns, villages and conservation areas* (2008);
- The *Law on the regulation of scenic sites (2006):*
- The *Law on the regulation of natural reserves* (2003).

4.2. Harmonisation with provinces and municipal regulations

The Ministry of Culture and the State Authority for the Cultural Heritage of China took charge, along with the eight provincial governments concerned, of the setting up of advanced heritage protection for the Grand Canal. A document setting out the basis for harmonisation between the towns along the canal – the Joint Agreement for the Protection of the Grand Canal – was signed and was implemented in 2012 for the main municipalities concerned. It guarantees the convergence of municipal regulations in town planning and building rules, and in the demarcation of protected areas, etc.

In practice, all elements next to the canal (passageways, bridges, house facades, trees) in the historic urban quarters are recognised and strictly protected as urban districts associated with the canal. In the ordinary sections of the linear course of the canal, with no specific attributes, the banks are considered to form part of the canal because of their technical role, and they are protected in the same way as the canal.

4.3. Buffer zone regulation

Immediately adjacent elements which play a role in the heritage integrity of the canal and its landscapes (trees, footpaths, facades, etc.) must be protected by the current buffer zones.

The buffer zones are intended to prevent building and development pressure in the most sensitive zones of the canal. Generally speaking, they are covered by the same regulation as the nominated property itself. When this is not the case, building density and height are regulated by the provisions of the local Master Plan.

5. Conservation and management

5.1. Conservation

The large amount of canal maintenance work and dredging carried out since the 1950s has demonstrated the revival in interest in waterways in China. Several of the sections included in the nominated property have been affected by this work. The associated documentation is available from the River Regulation Administration of the People's Republic of China, from provincial bodies and departments, and from municipalities and local authorities. The canals are currently carrying intense levels of traffic; in some cases, the canals have been widened, and in many cases new sections have been dug and new port facilities built. While their state of hydraulic conservation is usually good, the state of heritage conservation may vary considerably, as in some cases technical characteristics have been substantially altered, and landscape authenticity has been affected by the many sections passing through suburban or industrial zones, often developed because of the presence of the canal.

The non-navigable sections of the canals have often been kept as drainage reaches, to carry away rainwater and protect against flooding, and they are also used for irrigation purposes. They have thus been kept for water management purposes, but without any major structural alterations. These are the most authentic sections, and those most representative of the historic canal.

Conservation plans have been drawn up for each of the canals included in the nominated property; they provide for the construction of technical facilities whose materials and shapes are in keeping with traditional facilities, and the regulation of new building densities and heights mentioned above. Each plan acts as a guide of best practices for the restoration and maintenance of the canal itself, the associated hydrological zones (lakes, marshland, irrigation zones, etc.) and of its existing facilities. It also sets out a series of measures to improve environmental quality in general and water quality in particular, and is based on a plan for the distribution of water between the various zones along the Grand Canal.

Since 2006, systematic monitoring of the heritage conservation of the property as a whole has been added to the hydraulic management. A policy of encouraging archaeological excavations, with the conservation and protection of the remains unearthed, has also been developed.

In 2008, in response to the problems of economic and urban development in many zones around the canal, the provincial and municipal authorities agreed to coordinate a global conservation plan for the property, including control of urban development in the zones forming part of the nominated property and buffer zones (urban density, building height, industrial and logistical facilities).

6. Documentation, selective bibliography

6.1. Grand Canal inventory, records and archives

The nomination dossier (see UNESCO World Heritage website/List/Documents) notes 37 national, provincial or municipal data centres for Grand Canal records and archives. State Administration of Cultural Heritage, 83 Beiheyan Street, Beijing.

Some examples:

- Grand Canal Heritage Monitoring and Archive Center, Chinese Academy of Culture Heritage, 2 Gaoyuan Street, East Road, North 4th Ring Road, Chaoyang District, Beijing;
- Administration of Cultural Heritage of Shandong Province Province,12 Jingshiyi Road, Jinan, Shandong;
- Tianjin Municipal Administration of Cultural HeritageAddress: No.12 Chengde Road, Heping. District, Tianjin

6.2. Bibliography

Bibliography of the Grand Canal constitute an enormous corpus. It is presently a field of research. Again, the nomination dossier offers a precious international guide for any researches in the field. Titles of the original Chinese papers are translated in English. The bibliography summary classifies documents as follow:

- *Historic classics; e.g.:*
  - [Western Han Dynasty] Sima Qian, *The Historical Record* (Shi Ji), *Book of Rivers and Canal*;
  - [Eastern Han Dynasty] Ban Gu, *History of Han Dynasty* (Han Shu), Annals of Ditches in Fields;
  - [Tang Dynasty] Wei Zheng, *et al.*, *Book of Sui, Emperor Yang*; and etc.
- *Historic maps; e.g.:*
  - *Map Water Sources of the Grand Canal in Nine Provinces*, 1790, Zhejiang Press of Ancient Chinese Books, 2006, etc.
- *Annals of provinces and cities, e.g*.:
  - Gao Xiangxiu & Fan Shen (eds.), *Annals of Hejian Prefecture*, 1540;
- *Modern and Contemporary Literature; e.g.:*
  - Pan Yong, *Canals and Caoyun in Sui and Tang Dynasties*, Sanqin Publishing House, 1987; and etc.
- *International Literature, e.g.:*
  - Needham Joseph, ‘China and the invention of the pound lock’, *Transactions of the Newcomen Society*, 36, UK, 1963, 64;
  - Hanyuan Yao, *The Grand Canal: An Odyssey* (1987); etc.
  -

Other documents used for the present article:

- State Administration of Cultural Heritage, *The Grand Canal, World Heritage Convention Cultural Heritage Nominated by People's Republic of China*, 2013.
- ICOMOS evaluations, *The Grand Canal (China) No 1443*, 2014, 110.

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09. Chinese Taipei

Regional Overview: Promotion of water heritage in the region of Taiwan in last decades

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Introduction

After the 1990s, due to societal changes as well as reform of the cultural heritage preservation system, all types of water-related heritage have gradually been taken more seriously in the region of Taiwan, leading to the initiation of various activities such as research, preservation, and repurposing of water-related heritage by the government sector and academia. In recent decades, due to the immense pressure brought on by unanticipated weather and environmental changes, issues of water environment are steadily attracting more attention. In addition, starting in 2013, the International Council on Monuments and Sites (ICOMOS), the International Commission on Irrigation and Drainage (ICID) and the World Water Council (WWC) began discussing the notion of establishing a World Water System Heritage Programme, with the purpose of learning from the crystals of wisdom of the ancestors in water management to serve as the new cogitation in response to the changes and adjustments of water environment under extreme weather. Water heritage has, therefore, now become the new focus and new direction in the preservation of the cultural heritage in the region of Taiwan. This article will introduce the developmental journey of Chinese Taipei's cultural heritage after World War II, as well as shed some light on the developmental journey of Water Heritage in the region of Taiwan, in addition to presenting critical recent achievements.

1. Cultural heritage preservation and public participation in the region of Taiwan since the 1950s

1.1. System deviation in Taiwanese cultural heritage preservation during the period of 1950 to 1970

Between 1950 and 1970, the 'Regulation of Antiquities Conservation' was always the sole legal basis in the preservation of cultural heritage in the region of Taiwan. However, the sets of regulations stipulated in the 'Regulation of Antiquities Conservation' back in Mainland China in 1930 only cover antiques with regards to preservation types missing construction, intangible, or complex cultural heritage. Furthermore, due to prevailing circumstances, cultural matters were not a priority for the authorities as compared to national defence or economic development. All these factors contributed to the long-standing insufficiencies in both policies and measures of cultural heritage preservation in the region of Taiwan after the war, between 1950 and 1970 (Huang, 2017). This lack of adequate policies and measures had steadily showed signs of improvement along with the initiation of the 'localisation movement' in the 1970s.

1.2. Historic site preservation movement and public awareness raising

During the 1970s, along with the initiation of the 'localisation movement,' the Taiwenese public launched a series of 'Historic Site Preservation Movements' devoted to preserving ancient construction, specifically aimed at protecting old buildings in all Taiwanese areas that were gradually fading away due to modernisation. The initial driving force behind the movement came from academia, especially from teachers and students of construction and art departments in colleges and universities. After the 1980s, the driving force behind these historical site perseveration movements shifted to residents or community members in the local area, who cared deeply about these old constructions that had not only become a part of their everyday living, but possessed historical, cultural, and artistic values. Thus, they became heavily invested in the preservation of all old constructions (Hsia, 1998). As these movements progressed, the awakening of public awareness became clear. Using the preservation of old construction as the starting point, residents expanded their involvement with further demonstration of concern for all public matters involving their daily living. In the 1990s, appealing for 'public participation' and 'bottom up', residents redefined 'community development' with local features, laying down the foundational work (Yen, 2005).

1.3. Expansion of the cultural heritage preservation aspect: Drafting and amendment of the *Cultural Heritage Preservation Act*

The awakening of Taiwanese public's awareness towards cultural heritage preservation has affected the government sectors in policymaking and execution of cultural policies. In view of the increasing emphasis on cultural heritage by society, in 1982, the authorities announced the abolition of the obsolete *Regulation of the Antiquities Conservation*, at the same time announcing the drafting of the *Cultural Heritage Preservation Act*. Not only did this incorporate the antiques previously addressed in the defunct *Regulation of the Antiquities Conservation*, but the newly promulgated Cultural Heritage Preservation Act also expanded upon the cultural heritage preservation typologies as defined by law to include the preservation of buildings such as historical monuments, or beyond such as folk art and folklore, as well as natural landscape or other natural sceneries. Since its coming into force in 1982, the *Cultural Heritage Preservation Act* has undergone seven amendments. In the structural amendment in 2005, 'cultural landscape' was added as a new preservation type, which covers 'industrial landscape,' 'transportation landscape,' and 'hydraulic facilities,' etc. Through the history of the act's amendments, it is evident that the preservation of cultural heritage in the region of Taiwan has been dynamically expanding since the 1980s, to reflect evolving times and global trends. In continuation of this trend, it was possible to deem 'Water Heritage' as an emerging issue in the discussion of cultural heritage preservation in the 2010s.

2. The origin of water heritage preservation in the region of Taiwan between 1990 and 2010

Beginning in 2010, 'Water Heritage' has become an issue for discussion, heavily influenced by the increased attention received by the 'Industrial Heritage' movement and 'water-related heritage' between 1990 through till 2010.

2.1. 'Industrial heritage' and 'Water-related heritage'

The development of the preservation of 'water-related heritage' in the region of Taiwan is a possible outcome of 'Industrial Heritage' of the 1990s. Adopted from 'Industrial Archaeology' of Europe back in the 1960s, the purpose of 'Industrial Heritage' was to address all tangible or intangible forms that were undergoing a modernisation process, including: industrial plants, machinery, unused spaces, its developmental history, and recollections. The urbanisation and modernisation process that the region of Taiwan underwent after the war left a plethora of industrial heritage that had outlived its usefulness due to changing times and an industrial upgrade. Through the passage of time, they were forgotten by their people, or simply faded away. However, their historical depth and cultural value were not to be undermined (Lin, 2014). Entering the 1990s, along with the awakening of the awareness for cultural heritage preservation in the people Taiwanese people, industrial heritage had become a new focal point in this field. The preservation of the Roundhouse in Changhua Station (classified under transportation) and Taipei Brewery (classified under industry) illustrated famous cases of industrial heritage preservation in the 1990s. In response to the public's attention towards the preservation of industrial heritage, starting in 2002, the authorities began to investigate industrial heritage across typologies of electricity, sugar industry, oil, and hydraulics under the jurisdiction of government agencies or state-owned enterprises. A related investigation of 'hydraulic' industrial heritage became the origin for 'water-related heritage' research work in the region of Taiwan.

2.2. Research on water-related heritage: Participation of the Cultural Department and the Hydraulic Department

Within the framework of 'industrial heritage' preservation, research work commenced on water-related heritage. In 2003, the Ministry of Culture gave impetus to a project for the region of Taiwan to establish a list of potential World Heritage Sites based on standards (criteria) stipulated by Operational Guidelines for the Implementation of the World Heritage Convention,' consisting of: outstanding universal value, authenticity, and integrity. A total of 17 cultural, natural, or mixed potential heritage sites were selected, which included the cases of: Wushantou Reservoir, Chianan Irrigation Waterways and Taoyuan Tableland Mesa and Pond, as well as many other examples of water-related heritage (Tan, 2012).

The Hydraulic Department, which plays the role of user, manager, or owner of hydraulic facilities, had begun to pay attention to the value of water-related heritage. In 2007, the Water Resources Agency (WRA) of the Ministry of Economic Affairs (MOEA) pushed for a 'Cultural Heritage Investigation' project, aiming that all water-related heritage needed to be under the ownership of various hydraulic agencies, initiating multiple investigations related to various types of heritage, which included: settlements, sites, cultural landscapes, natural landscapes, literature, oral historical material, construction, and civil engineering facilities, machinery. A comprehensive water-related heritage list consisting of 1,898 items was ultimately formulated (Huang, 2008). In 2008, the WRA of MOEA initiated the project, 'Oral History for Water Resources,' that involved interviewing present or retired employees of hydraulic agencies across all levels, documenting the crucial memories of these professionals spanning their careers. These two investigative tasks served as the impetus of the water heritage investigation and research in the 2010s (Ku, 2009).

3. The journey of water and heritage preservation in the region of Taiwan from 2010 to 2019

Beginning in 2010, encouraged by discussions between ICOMOS, WWC, ICID, the Heritage Irrigation Structures (HIS) and the World Water System Heritage Programme (WSH) on the relevant authentication for water-related heritage, the authorities of Taiwan adopted water heritage as a main theme in pushing forth a series of preservation, research, and repurposing projects. At the same time, water heritage also assumed a new importance being incorporated as a new typology in Taiwanese cultural preservation. The driving force for this first emerged from the Bureau of Cultural Heritage within the Ministry of Culture and the Water Resource Agency of the Ministry of Economic Affairs.

3.1. Case studies with value interpretation

Starting in 2010, different sectoral authorities in the region of Taiwan began pushing for the investigation and research on water heritage, not just simply investigating and inventorying, but focusing on the establishment of a new set of interpretation benchmarks and discourse of values. Different from interpretation of the past that centred on historical, economic, societal, and industrial aspects, this interpretation benchmark returned to the most basic and necessary structure of cultural heritage – 'water.' Utilising 'water' as the core concept, these cases are reinterpreted to uncover its true position in human civilisation. In the discourse of values, research on water heritage is different from traditional cultural heritage research, with the focus on the extraction of past-verified wisdom and experience on water heritage, and then using this as a response to water environment when dealing with climate change in the future. In terms of research methodology, in tune with UNESCO World Heritage and

WSH's 'systematic' interpretation benchmark, the idea was to move beyond the 'à la carte' structural object cultural heritage investigation habits of the old and attempt to use 'water resource system' as the scope for case studies and interpretation.

Fig. 1: Shigang Dam which was built from 1974 to 1977 for flood control and irrigation purposes. (Dajia River Catchment Water Works).

This was how in the 2010s, water heritage investigation and research were initiated by the Ministry of Culture. Between 2014 and 2018, the Bureau of Cultural Heritage, Ministry of Culture used the cases of 'Tamsui River Catchment Water Works,' (TIIWE, 2015) 'Dajia River Catchment Water Works,' (TIIWE, 2015) 'Taichung Unified Hydro System,' (TIIWE, 2016a) 'Taoyuan Tableland Waterway System,' (TIIWE, 2016a) and 'Yunlin-Chiayi-Tainan Delta Area' (TIIWE, 2018a) in succession to investigate all water heritage remains which possess preservation value in these research areas, collecting relevant literature and historical materials as well as conducting oral interviews with the elderly, then attempting to interpret the true value of these cases using 'water' as the basis, thereby establishing a discourse of value on water heritage.

Fig. 2: The inverted siphons of Baileng Canal, constructed in 1927, transported water from Dajia River through mountains and valleys and to the farm terraces (Taichung Unified Hydro System).

Fig. 3: Wushantou Reservoir and the headrace channel of Chianan Irrigation system built in the 1920s to promote the agriculture of Yunlin, Chiayi, and Tainan area (Yunlin-Chiayi-Tainan Delta Area).

The water sector had also devoted itself to the investigation and research of water heritage. In 2015, the Water Resources Planning Institute of WRA investigated the 'Zhoushui River Alluvial Fan' and 'Changhua-Yunlin-Chiayi-Tainan Coast Reclaimed Area.' In 2016, using verification standards stipulated by WSH to determine its value some parts of the results were submitted to ICID as preparation data for applying for recognition of WSH (TIIWE, 2016b). The Northern Region Water Resources Office of WRA used Shihmen Reservoir, a historically important hydraulic facility under its jurisdiction as the primary theme for a case study. The investigation method used centred on the organisation and interpretation of the agency's archived files as well as cutting in from a 'systematic' research perspective, touching on relevant hydraulic facilities in the downstream/upstream of Shihmen Reservoir and Dahan River, thereby creating a set of water heritage value discourse with 'Dahan River Hydraulic Family' at its core (TIIWE, 2018b).

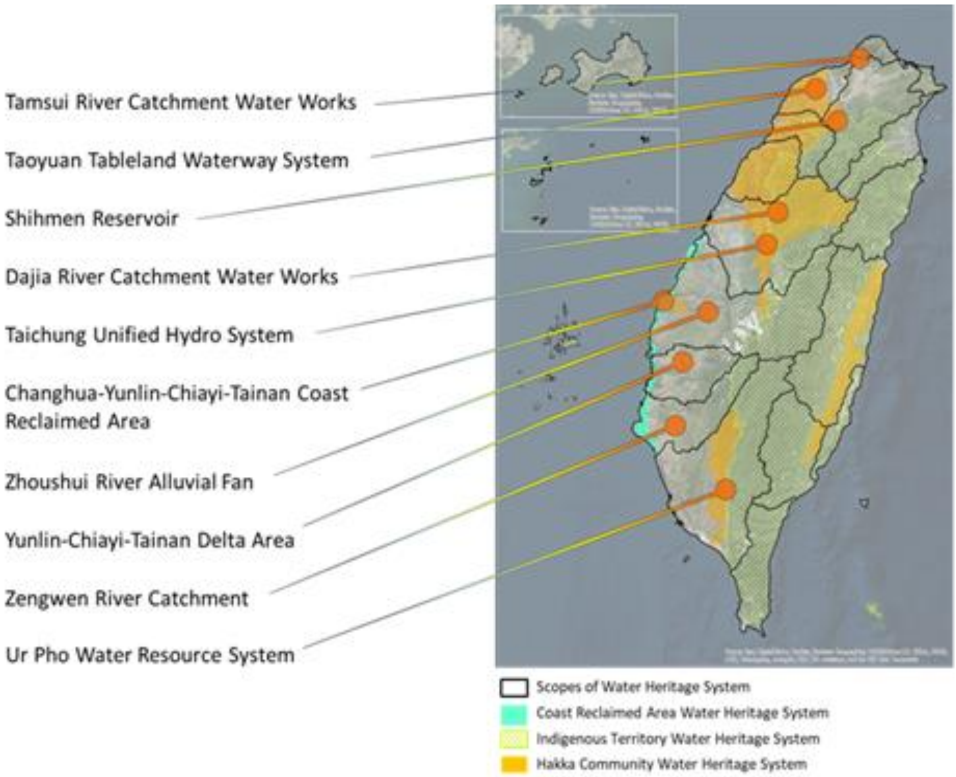

Fig. 4: The outcomes of water heritage research in the region of Taiwan (2010–2020).

3.2. Attempt at cross-sector collaboration

Fig. 5: Exhibition of Float or Sink: Water Culture at National Museum of Taiwan History in 2019.

Between 2017 and 2018, the Water Resources Planning Institute used 'Zengwen River Catchment' as a case study to conduct a water heritage research project (TIIWE, 2018c). Through collection of historic material, field investigation, and the interpretation of an old map from the Japanese Occupational Era, the institute explored the evolving journey of the water environment under natural conditions such as: landscape, climate, and hydrology. This project also probed into subsequent water works that were established as a response to uncover the potential highlights of water heritage that possess preservation, research, and promotional value, thus allowing the extraction of water / cultural experience and wisdom to serve as a reference for the hydraulic department in performing water resource planning for the future. Notably this project facilitated an opportunity for collaboration between the Ministry of Culture and the Hydraulic Department. With the cross-sector collaboration between the Water Resources Planning Institute and the National Museum of Taiwan History, the research results gathered from this project were utilised to create an exhibition for the museum as well as a public participation activity titled 'Float or Sink, water culture in Taiwan,' in which the purpose was to create an opportunity for the public to gain a deseper understanding of the value of water heritage. This is the first jointly devised exhibition by the Hydraulic Department and the Ministry of Culture (Fig. 5), which serves as a crucial milestone in the promotion of water heritage (TIIWE, 2019a).

3.3. Involvement of society

Aside from the impetus from the government sectors, results have been achieved from public professional organisations with regards to water heritage. In the 'Workshop of Water and Heritage for the Future' in 2017, which took place at the time of the 19th ICOMOS General Assembly that was held in New Delhi, India, issues such as the establishment of an International Scientific Committee for relevant water heritage and the organisation of a water heritage international symposium were discussed. With the support of representatives from different countries, Chinese Taipei acquired the opportunity to host this international water heritage symposium. Named as the '2019 International Conference 'Water as Heritage,' this was hosted by the Taiwan International Institute for Water Education (TIIWE), inviting relevant professionals and international organisations in the field of cultural heritage and nature from all over the world to collaboratively discuss the issue of 'water and culture,' as well as develop cross-sector and cross-department online works to serve as the forward-looking vision for the international network in advocating water heritage issues.

4. Current stage results (2010–2019)

4.1. Establishment of preservation discourse and theoretical system

In the process of Taiwanese cultural heritage case investigations, both the academia and government sectors attempted to establish a preservation discourse and an evaluation standard of values. Through the collection of literature, oral interviews, and field investigations on cultural heritage from various areas, coupled with the uniqueness of the Taiwanese climatic and geological environment, a 'National Water Heritage Value Discourse' was formulated, which included chapters such as 'Window to Environmental Changes Around the World,' 'Melting Pot of Technology,' and 'Lighthouse for Vanguards.' Using the results of case investigations from various areas as the basis alongside referencing the content of the World Heritage Registration standard, the International Water Heritage Registration standard, and Taiwanese 'Cultural Heritage Preservation Act,' five aspects were included in the formulation of Taiwanese water heritage value evaluation standard, which are: 'historical value,' 'social functionality value,' scientific value,' 'art & aesthetic value', and 'overall value.' (TIIWE, 2018a)

4.2. Application of added value and repurpose

In encouraging water heritage preservation research, the application of added value is a crucial segment. To allow the public or interest groups to get a grasp of relevant knowledge and research concerning water heritage within a short time, the water heritage research led by the government sectors has developed various forms of added value applicability. For example, in the 'Reference Manual for Preservation and Promotion of Water Heritage in Taiwan' proposed by the Bureau of Cultural Heritage, the Ministry of Culture, not only introduces the origin and definition of water heritage, but also brings in the angle of featured values of Taiwanese water heritage to offer a reference for devoted water heritage preservationists (including individuals, groups, or organisations) that are involved in investigation or preservation tasks. Aside from the manual, the Bureau of Cultural Heritage, Ministry of Culture has created a table game teaching material specifically centring on the Taoyuan tableland's water heritage of pond. Designed for junior high school students or older, this set of teaching materials, through an edutainment method, allows the players to simulate the developmental conditions of predecessors of Taoyuan tableland, enabling an understanding of the developmental history of the land as well as the predecessors' intelligence in water usage (TIIWE, 2018b).

The Northern Region Water Resources Office currently holds many documents on Shihmen Reservoir in its archives; these serve for the promotion and repurposing of 'Water Heritage in Shihmen Reservoir.' Currently, the concrete results from added value and repurposing are presented in two volumes of 'Water Heritage in Shihmen Reservoir.' One volume links different files (especially old images and documents) to present these through a narrative method (Fig. 6), while the other volume utilises the developmental historical context of Taoyuan tableland as the basis to illustrate the developmental journey of Dahan River and Shihmen Reservoir's environment through a water heritage perspective, as well as highlighting the water heritage value of the 'interaction between human beings and the water environment.' (Fig. 7) (TIIWE, 2019b)

Fig. 6: The book of 'The archive stories during Shihmen Reservoir construction period'.

Fig. 7: The book of 'Learning Water Heritage from Shihmen Reservoir'.

4.3. International exchange of experience

The activation of Shihmen Reservoir in 1964, linked the pond of Taoyuan tableland of the early seventeenth century and Taoyuan Canal that was constructed during the Japanese Occupational Era, providing a livelihood and industrial water for the 5 million residents in northern Taiwan. Being affected by climate change in recent years, water resource management whenever Shihmen Reservoir is faced with flooding or drought must be carefully considered. In recent years, Shihmen Reservoir has spared no efforts in the push for environmental education as well as preservation and research on water heritage. As a result, Shihmen Reservoir was honoured with the Water Heritage Awareness Shield from ICOMOS Netherlands in 2017 (Fig. 8), affirming the regional work for water heritage preservation.

Fig. 8: Water Heritage Awareness Shield in Shihmen

5. The steps and potential momentum of water and heritage in the region of Taiwan in the future, beyond 2020

5.1. Preservation, research and interpretation of literature and assets in water works

Hydraulic agencies at all levels in the region of Taiwan, including the Water Resources Office, River Management Office, and Water Resources Planning Institute that are under the jurisdiction of the Water Resources Agency, MOEA, as well as the Irrigation Association (once owned by the private sector) and some of the agencies all date back to the Japanese Occupation period. These hydraulic agencies archived a large amount of literature, consisting of documents, engineering plans and designs, construction reports, maps, old photographs, etc. This literature was not valued by the hydraulic departments in the past. Lack of research and interpretation from academia, led to the loss of literature with the passage of time. Since the push of water heritage perseveration and research in the region of Taiwan began in the 2010s, hydraulic agencies at all levels have begun seeking the true value of water heritage in their possession. An attempt to digitise this literature was thus enforced to permanently preserve them, in addition to adopting an 'open data' approach to allow access to all. Therefore, the preservation, research, and interpretation of these archived water sources at various agencies will offer an important impetus for water heritage in the region of Taiwan in the future.

5.2. The push for water heritage from local agencies

Between 2010 and 2020, the driving force for Taiwanese water heritage agenda was primarily derived from the central authorities. Starting from 2020, this force will spread from the central to the local, in which hydraulic departments of local governments are expected to begin to concentrate on rivers and waterways in their respective jurisdiction, pushing for water heritage research projects. Some projects for example, are 'Gongsitian Creek,' 'Shumeikeng Creek,' 'Lujiao Waterway,' and 'Huocun Drainage,' etc. of New Taipei City, 'Laochie River' in Taoyuan City, as well as 'Fazi River' and 'Luchuan Waterway,' etc. of Taichung City.

5.3. Water heritage narratives: From grand narrative to 'petits récits'

Compared to the grand scale, cross-region water system investigations, such as Tamsui River, Dajia River, and Zengwen River, conducted by the central authorities in the 2010s focused on the interpretation and suggestion of Grand Narrative in regard to water heritage value. The water heritage research project which is offered by the local hydraulic departments in the 2020s will focus on the local departments' practical operational aspect, such as safeguarding the environment, river ecology, encouraging public participation, as well as interpreting the connection between water heritage and district development from the perspective of 'localogy' and 'petits récits'. Such changes do not mean that the grand narrative of Taiwan's water heritage is completed, but instead it should be interpreted as that the process of establishing a water heritage narrative in the region of Taiwan will depend on the continuous inventorying of grand narratives and 'petits récits' from various areas, thereby enriching the content of grand narratives, adequately reflecting the diverse nature of culture in the evolving journey of Taiwanese history.

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Case study 1: Babao Canal

By Ya-wen Ku, Associate Research Fellow, Institute of Taiwan History, Academia Sinica

Introduction

Babao Canal (八堡圳), drawing water from the Zhuoshui River and running across the Changhua Plain in central of Taiwan Island, was the largest irrigation canal in the area under Qing rule (1684–1895). As a peripheral small island of the Qing empire, the island of Taiwan had more than 1,000 irrigation canals, most of which were built by settlers from south-eastern China, rather than by the government. Among them, Babao Canal was the result of a bold investment by a rich family with an adventurous spirit and business acumen.

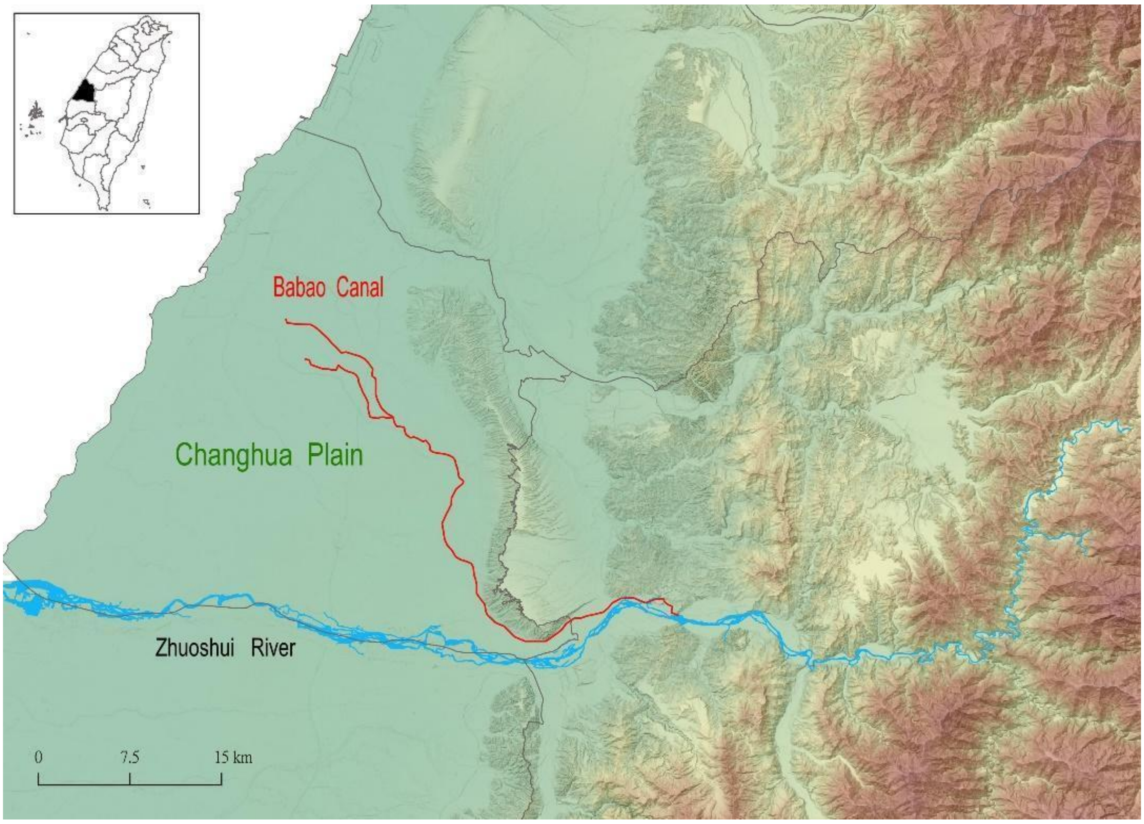

Fig. 1: Babao Canal in the Changhua Plain. © *Ya-wen Ku.*

1. Brief history

It took 10 years for the canal to be completed. The successful construction of the canal was a dramatic story, with local legends and poetry filling in the details. In the early eighteenth century, the Shih family, that settled in southern of Taiwan Island in about 1693, had accumulated a large amount of capital from the sugar trade, and had also acquired experience of cultivating rice paddy. Realising the possible business opportunities from the rising rice price, the 39-year-old Shih Shih-Bang followed immigration to the Changhua Plain in 1709 and started his reclamation and irrigation project. Shih provided capital and recruited local tenants to build irrigation facilities but failed repeatedly at a most critical part of the work, the 'canal headwork'. One day, an old gentleman suddenly appeared. With the help of his instructions and informative maps, the project was finally completed in 1719. After the project, this mysterious man disappeared, leaving behind only his last name, Lin.

2. Traditional water wisdom: Adaptation to the environment

Although Mr Lin's presence bordered on myth, the techniques taught by him are quite scientific. First, Lin suggested that a series of lanterns be hung at night to judge the terrain by light and shadow, to make the ground into a suitable slope for water diversion. In addition, he instructed the locals to weave the locally sourced bamboo into cone-shaped cages, put rocks into the cages, and place them one by one on the riverbed of the tributaries to form several dams; all of which were based on his good understanding of the hydrological state of the Zhuoshui River, characterised by braided courses and seasonal variation in water volume.

During the dry season in fall and winter, since the streamflow was extremely low, the dam cages, or so-called 'Tsio̍h-Kô (石笱)' served to block the tributaries, so as to concentrate the flows, raise the water level and divert water to the canal. Straw was used to fill the space between stones to reduce leakage. During the wet and typhoon season, after flooding, the temporary dams would be naturally washed away, to avoid inundating the farmlands along the canal. After the floods, the canal headwork with a modified driving channel could be immediately constructed using Tsio̍h-Kô. Traditional water wisdom could be seen as a means of innovation which integrated techniques inherited from the hometown of immigrants and local knowledge gained from observing the unique water environment in Taiwan Island.

Fig. 2: Using 'Tsio̍h-Kô' for construction of the Babao canal headwork (about 1960s). *Source: Online Digital Collections of Old Manuscripts and Photos in Ershuei Township.*

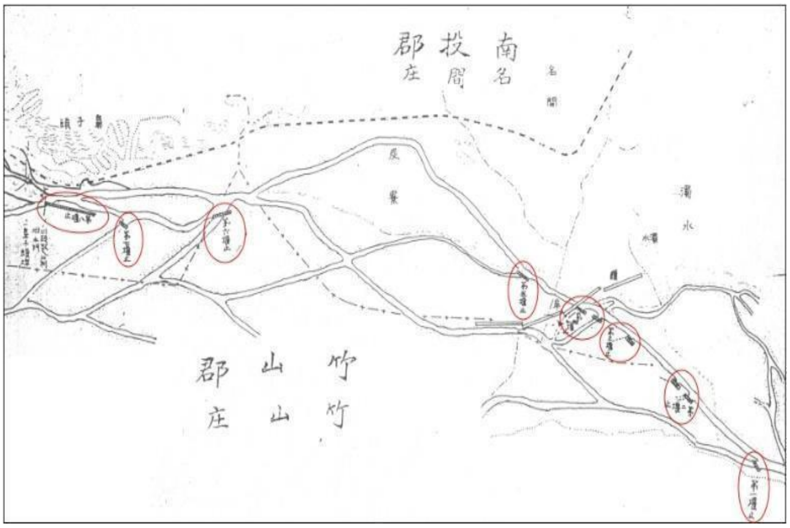

Fig. 3: The *'Tsio̍h-Kô'* were placed on the riverbed (red circles) to form several dams. © *Yawen Ku (2000). The Interaction between Human and Nature – a Case Study of Babao Canal. MA. National Taiwan University.*

3. Operating with cooperation

The Shih family's irrigation canal watered more than 10,000 hectares of land which spanned 8 of the 13 administrative units in Changhua, thus earning the name 'Babao (Eight Baos) Canal' thereafter to reflect its scale. The canal brought together immigrants with different surnames from various places to form a 'water community', which reached a consensus on the ways of cooperation. By signing contracts with the canal holder Shih, peasants became canal tenants and paid fixed amounts of grain crops annually (water tax), and sometimes provided labour services, in exchange for a fixed volume of irrigation water. The Shih family, on the other hand, was responsible for financial support for the irrigation repair works by hiring a manager to oversee the annual repair of the canal headwork, daily maintenance of channels, as well as water allocation.

With local cooperation, and a generally accepted order during the Qing period, the canal was successful and contributed significantly to the history of Taiwan Island. Since two crops of rice could be grown per year on the irrigated lands, the Changhua Plain became the most fertile barn of the region of Taiwan. The island transformed itself from having food shortage to being able to export rice to Mainland China, making Lukang Port into a major commercial city. The success of Babao Canal made it a role model to be replicated in other regions. Since then, relatively complex, challenging, and expensive canals soon outnumbered simple ponds. Thus, historians refer to the excavation of Babao Canal as the starting point of the paddy field movement of this island.

4. Sustainability: Cultural value of the Babao Canal

In 1902, the 8th year of the Japanese colonial period (1895–1945), the Babao Canal was evaluated to be of public interest and designated as a public canal. Subsequently, especially during wartime and the post-war period, the canal was 'modernised' by the public sector to improve efficiency to fulfil national policies of agricultural and industrial production. The old earth canals and Tsio̍h-Kô were gradually replaced by concrete structures after government intervention. This led to a separation between the locals' daily life and the canal.

In 1995, the traditional worship ceremony of the Babao Canal was revived as a main event at the Taiwan National Festival of Culture and Arts, aiming to invoke awe and gratitude for the canal. Since 2003 it has been part of an annual festival held by the local government and Irrigation Association in Changhua County. The Running Water Festival is a successful tourism promotion strategy though just the first step in the process of heritage conservation. Today, the 300-year-old canal remains the key to Changhua's role as a leading agriculture county. There is a further need for scholarly and public discussions on 'waterscape biography' of the canal to strengthen the sense of identity amongst locals and the relevant authorities. Moreover, a deeper understanding of Babao Canal's intangible cultural value and contribution towards innovation, inclusiveness, and cooperation, will highlight its educational potential as a significant cultural heritage of water.

Fig. 4: Intake of the Babao Irrigation Canal (built in 1932). © *National Cultural Heritage Database Management System.*

Fig. 5: Running Water Festival in 2018. © *Official website of the Running Water Festival.*

Case study 2: Sustainable wisdom in water irrigation engineering: Erfeng Irrigation Canal System of interflow water in Pingtung on the island of Taiwan

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Introduction of Erfeng Irrigation Canal System (EICS)

The Erfeng Irrigation Canal System (EICS) in Pingtung County, on the island of Taiwan, was constructed by the Taiwan Sugar Company (Japanese owned) in 1923 to irrigate sugarcane plantations and rice fields during Japanese colonial rule. It was designed by Engineer, Shinpei Torri.[11] The purpose of constructing EICS and its underground weir was to collect interflow water under the riverbed of the Linbian River to solve water shortage during the dry season in the Pingtung Plain. The year 2020 marks the 97th year of EICS operation with a fully functional irrigation canal system that continues to be used for irrigation purposes.

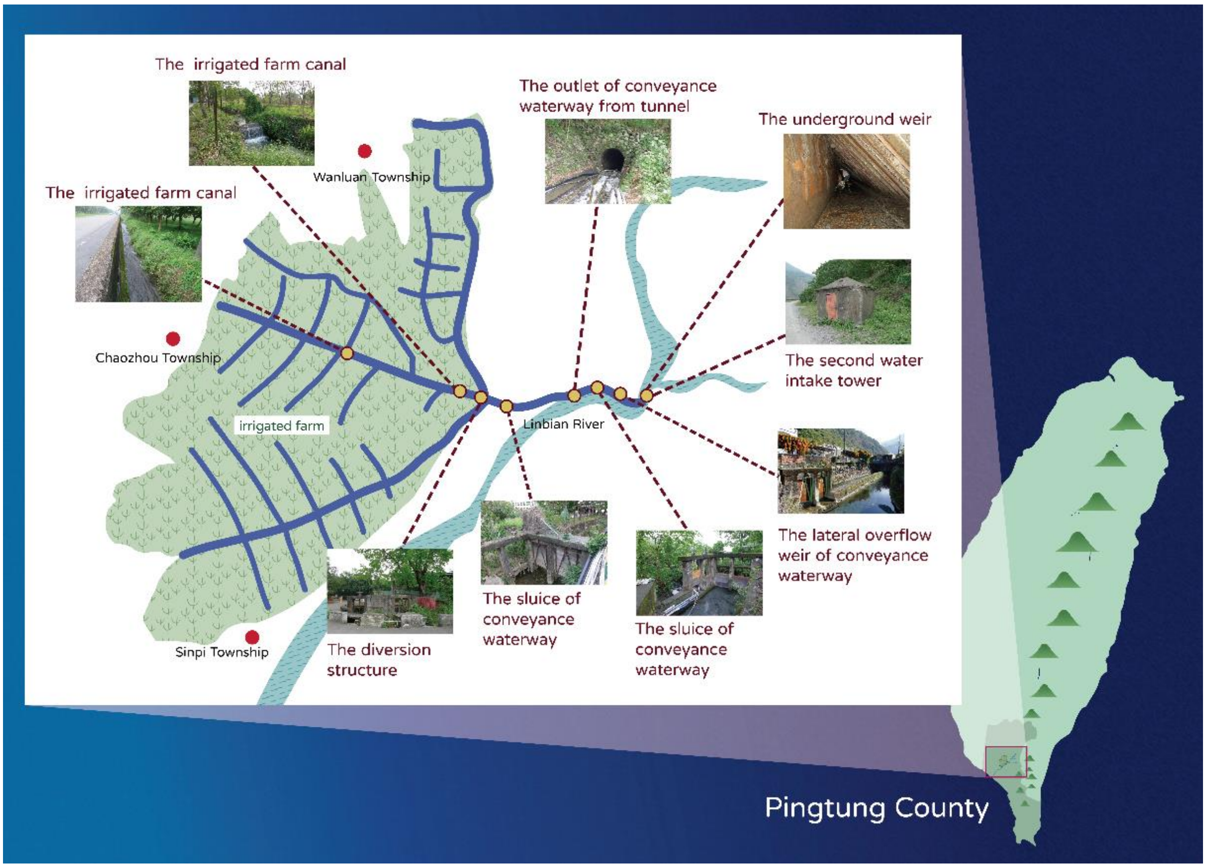

Fig. 1: The location and layout of EICS.

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The underground weir of EICS consists of four parts: a trapezoidal weir, an arched tunnel, a catchment culvert, and two water intake towers (a water intake tower is translated from Japanese and functions as a manhole for maintenance access). The foundation of a water intake tower is laid underground with the rest of its structure extending above ground. The trapezoidal weir, arched tunnel, and catchment culvert are laid to a depth of about 2 to 7 metres beneath the alluvium gravel of the riverbed. The trapezoidal weir is 2.87 metres high, 0.91 metres wide at the top, increasing to 3.94 metres width at the bottom. Its water intake surface consists of inclined concrete columns arranged to create a 25 per cent slotted seepage surface, forming a right-triangular water channel that is 1.82 metres wide at the bottom with a height of 1.82 metres. The trapezoidal weir, the main structure of the canal system, has a total length of ca. 328 metres, stretching from east to west at a gradient of 1/100. The western end of the weir is connected to the eastern end of the arched tunnel, which allows interflow water from the weir into the water intake tower. The tower, which is the endpoint of the structure, is ca. 1.5 metres in width and 8.4 metres in height. The interflow water flows from the arched tunnel through the water intake tower and eventually enters the water diversion structure. The water channel of the diversion system is ca. 3.6 kilometres long. The irrigation water is divided into three irrigation routes for farms by the installation of the diversion structure (Fig. 1). In 2017, the underground weir in EICS was part of a large-scale excavation and restoration project. The construction of the underground weir could be thus recognised in EICS (Fig. 2 and Fig. 3). Predominantly, the canals continue to be maintained by the Taiwan Sugar Company which was inherited from the Japanese after World War II though the farms no longer grow sugarcane. Water in EICS is deployed for farming and for serving the communities' daily water. Some of the water is also used by the local aboriginal communities.

Fig. 2: The construction of the underground weir in EICS. © *Cheh-Shyh Ting, 2017.*

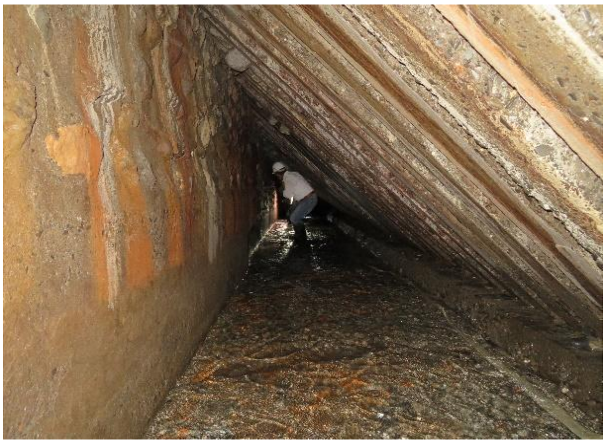

Fig. 3: The inside of the underground weir in EICS. © *Cheh-Shyh Ting, 2017.*

1. Conservation of EICS

In 2008, EICS was registered as a cultural landscape under the Cultural Heritage Preservation Act because it qualified as an industrial heritage of scientific value. Although the EICS does not exhibit a high degree of artistic value as cultural heritage, it nevertheless demonstrates advanced scientific value. Additionally, the Japanese designed the EICS to conform to the regional landscape and climate, enabling the successful provision of irrigation water and improving the yield of sugarcane. Though the irrigation canal structure is not an elaborate work of art, from a current sustainable and ecological engineering viewpoint, its precise water facility design and technological features demonstrate its scientific value. Thus, the details of this irrigation canal design are worth teaching to future generations (Fig. 4 and Fig. 5). The original design drawings which are important historical archives for this cultural heritage are conserved in Taiwan History Archives.[12] Furthermore, discussions on the conservation of EICS are covered in the academic journal articles in 2014[13] and 2019[14] authored by Lin and Ting.

Fig. 4: Lateral overflow weir, EICS.
© Szu-Ling Lin, 2020.

Fig. 5: Main ditch of EICS.
© Szu-Ling Lin, 2020.

Nowadays, maintaining and using water as a resource has become a major focus of human activity. Systems of land reclamation, water supply, irrigation, submergence, sewage, and the power of water help build, define, and sustain society. Water control has long been a strategic social, and political consideration for communities. Diplomatic function is also achieved via water heritage conservation. The precise design and construction of the EICS Project demonstrates sustainable and ecological thinking a 100 years ago. The value of science and technology in a 'cultural landscape' in 2008 has been shaped for academic and cultural exchanges between Chinese Taipei and Japan. This is the basis for sustainable management as well. For the people of Chinese Taipei and Japan, this has also led to establishing historical sentiments. During certain festivals related to EICS, both parties have actively participated and continued to be involved in this water-based cultural heritage.

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10. Vietnam

Case study 1: Mu Cang Chai Rice Terraces and its water management

By Ho Ngoc Son, Bui Tuan Tuan, Thai Nguyen University of Agriculture and Forestry, Vietnam

Fig. 1: Ripe rice terrace in Mu Cang Chai in 2020. © *Ho Ngoc Son.*

Introduction

Mu Cang Chai is among the rural districts of Yen Bai province, about 350 km to the north-west of Ha Noi and is best known for its rice terraces. Mu Cang Chai is home to several ethnic minority groups, but the H'mong group accounts for over 91 per cent of its population (Yen Bai Gov., 2019). Mu Cang Chai terraced fields span more than 2,300 ha at a height of 1,000m above sea level in Hoang Lien Son Mountain Foot (Yen Bai Gov., 2019). The history of the formation of terraced fields in Mu Cang Chai is associated with the residence history of the H'mong people, the first owner of this land (Yen Bai Gov., 2019). H'Mong people from Lao Cai, Ha Giang migrated in the mid-eighteenth century with four major groups: Mong Do, Mong Du, Mong Linh, and Mong Si. The distinction between H'mong groups, in addition to the characteristics of clothes, is based on the characteristics of language and customs.

Mu Cang Chai takes its own geological characteristics with steep feature, fertile soil and mountain cliffs often stock water, so local people can grow rice and establish terraced fields from the foot to nearly the top of mountains (Hai *et al.*, 2010). This explains why the H'mong people have to take advantage of low hills with large areas, moderate slope, and both rain and water from streams leading from high elevations to low fields to form terraced fields. The Mu Cang Chai terraced landscape is representative of a living culture's harmonious interaction with nature. The indigenous culture has transformed the mountain's harsh natural conditions. Terraced rice fields in Mu Cang Chai coupled with distinctive cultural practices of local ethnic minority groups have created the uniqueness of the locality (Anh, *et al.*, 2020). In 2007, the Vietnam Government recognised 500 ha of terraced fields in 3 communes of La Pan Tan, Che Cu Nha and De Xu Phinh as a national Heritage site (Yen Bai Gov., 2020; Cuong, 2020). Mu Cang Chai terraced fields have long been well-known and considered a must-visit place for tourists to the north-western region of Vietnam (Diem, 2017; Chi, 2020).

Fig. 2: Green rice terrace in Mu Cang Chai, 2020. © *Ho Ngoc Son.*

1. Rice terraces as an indigenous water management approach in the upland region

The rice terraces are a great system of irrigation and water management that are rooted in the depths of the H'Mong culture. The terraced rice fields have been created by people living in mountainous and hilly terrain, where there is a shortage of flat land for rice cultivation (Anh *et al.*, 2020). They chose areas with gentle slopes and advantage positions for receiving rainwater and stream water, changing them into spectacular terraced rice fields. This is evidence of the creativity of local ethnic minority people in adapting to the local climate, soil, and irrigation conditions (Diem, 2017). Since water and irrigation systems play a vital role in the rice field, the local farmers were required to develop sophisticated water distribution channels to deal with the lack of water resources and the specific topography at high attitude. They used bamboo pipes to draw the water from the mountain, at 1,000 metres above sea level, while keeping it from flowing downhill.

Water starts from jungles in Che Tao Nature Reserves – the highest point of Mu Cang Chai – and streams start from Hoang Lien Son National Park. Over hundreds of years, water has seeped through bedrocks and the underground water system into the valley of Mu Cang Chai district, creating a system of natural streams and waterfalls with pure clean water sources. From these streams, the H'Mong people have come up with the initiative to use indigenous knowledge and local materials to store and bring water to the village for daily needs and agriculture production. Since the eighteenth century when they migrated here, and science and technology were not yet developed, they have used their experience and available local materials – an optimal initiative. Up to now, due to geographical separation, high technologies could not be used. Therefore, the initiative of people in using their indigenous knowledge in the conservation and use of water resources is still valuable. Water is brought to the village by bamboo stalks and natural gravity. From an upper hill, water is stored in a small hole where a bamboo pipe starts the water flow. The bamboo is cut in-half and used as a means of transferring water by natural gravity to the terraces. According to the experience of the **H'Mong people** in this matter, the water is routed to the first terrace and then an east opening to irrigate the lower terrace. This process avoids flooding the fields and preserves the fertility of the soil. This type of agriculture has not only allowed the local people to increase the cultivable area on steep and rugged mountainous terrain but also showed the knowledge and behaviour of people with natural water sources (Anh *et al.*, 2020).

Fig. 3: Rice terrace hill developed for tourism in Mu Cang Chai 2020. © *Ho Ngoc Son.*

2. Existing and emerging threats

Decreasing water supply is one of the major threats to the sustainable development of rice terraces in Mu Cang Chai. The local authority reported that during the last five years, the lack of water for paddy rice cultivation was common (Mua, 2017). For example, in La Pan Tan commune in 2020, at least 6 hectares of rice land had to be transformed into growing corn due to a lack of water. One of various reasons is that the increase of population and services requires more water sources and leads to less water being available for rice cultivation. Furthermore, local business developed many services and infrastructures to meet the demand of increasing numbers of tourists coming to visit the rice terraces each year. This may generate issues relating to physical deterioration, commodification and commercialisation of local culture for tourism purposes, and ruptures in the linkage between rituals and the values they embody. (Le, 2018). Finally, the loss of land cover is a major cause of freshwater loss. Illegal loggings in recent decades have caused the loss of land cover – the most important criteria for underground water recharge. On the one hand, the low recharge proportion leads to a low volume of underground water and the low flow rate of streams and waterfalls. On the other hand, the loss of land cover causes flash floods and landslides hazards. In Mu Cang Chai, flash floods and landslides have damaged the rice terrace heritage in the last few years (Pham *et al.*, 2017, 2018). These hazards not only damage people and construction but also the heritages. The impacts of climate change leading to increased rainfall in a short time might raise the high risk of landslides and flash floods as witnessed in 2017 (Richard, 2017).

Fig. 4: Rice terrace and flower circle for tourism in Mu Cang Chai, 2020. © *Ho Ngoc Son.*

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Case study 2: The Red River Dikes in Northern Vietnam

By Hieu Phung, Environmental Historian of Vietnam at the University of Michigan Center for Southeast Asia Studies

Since the first local Vietnamese rule was established in the Red River Delta in the late tenth century CE, dikes have become a distinct feature of riparian communities. Depending on the types of dikes to be considered, statistics vary on the existence of 3,000 to 5,000 km of dikes in a delta covering approximate 15,000 km^2 (Fig. 1). This case study underlines the urgent need for recognising the age-old Red River dikes (Vietnamese: *đê Sông Hồng*) not merely as a construction system for flood control but also as a site for water heritage. A long history and strong connections of this site with northern Vietnamese people poses a question of whether Vietnam should continue in its efforts to reshape the system to address urban expansion. Alternatively, should the nation focus on sustainability to reinforce a culture of dike maintenance amongst riparian communities ?

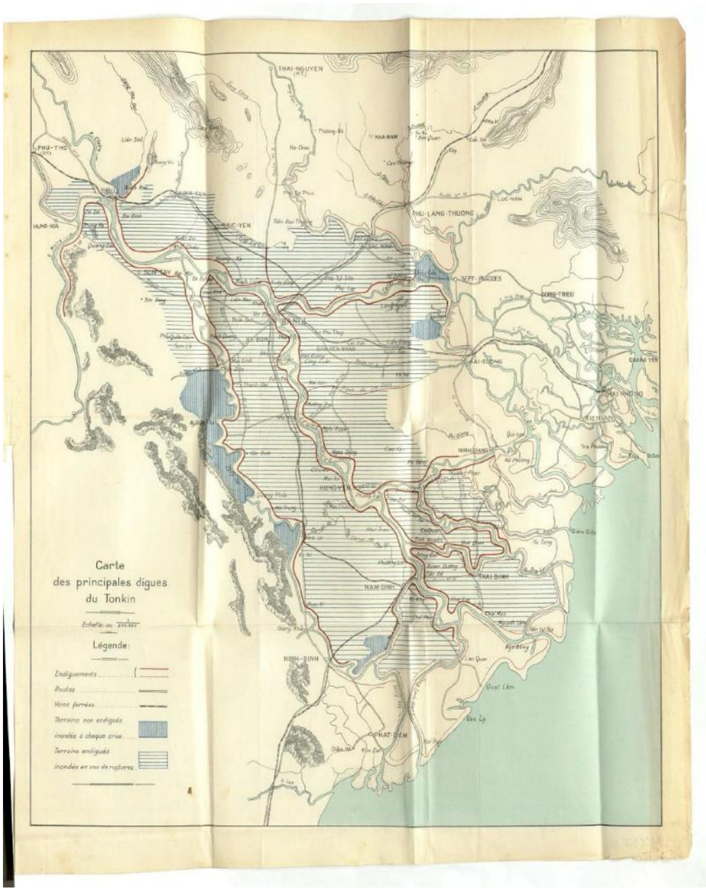
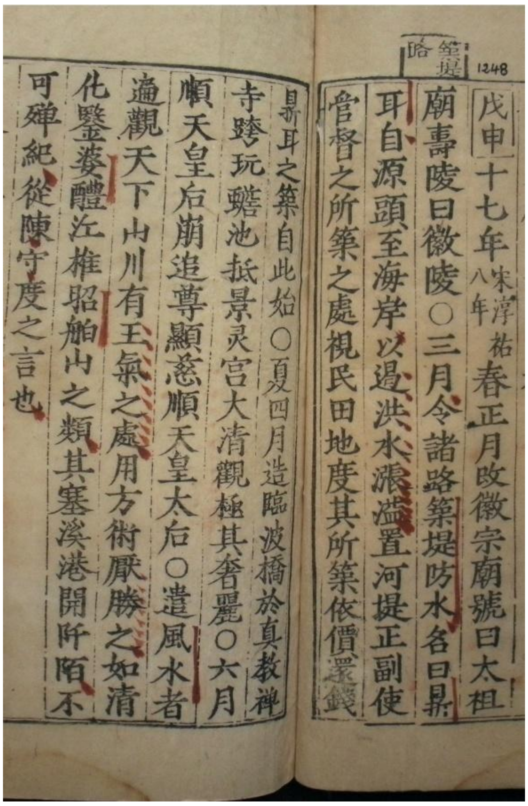


Fig. 1: The Red River dikes as observed in the 1920s. Red lines represent dikes. *© J. Gauthier, Travaux de Défense Contre Les Inondations: Digues du Tonkin (Hanoi: Imprimerie d'Extrême-Orient, 1930).*

Red River Delta dikes are understood to have first appeared as a technology transmitted from northern China. Earlier systems dating from the twelfth century constructed around Thăng Long (present-day Hanoi) laid the foundation for these dikes. Of these, the Central Sector of the Imperial Citadel was nominated on the World Heritage List in 2010. Local written sources such as the *Việt Sử Lược* [Concise Summary of the Vietnamese Historical Records] confirm, for instance, that in 1103 the Vietnamese ruler commanded 'people both inside and outside the royal city to construct dikes for flood control.'

The Red River dike system was not built all at once but rather evolved as an adaptive strategy to the changing environment. Chronicle records of climatic events such as drought and floods in Vietnam's famous dynastic history, *Đại Việt Sử Ký Toàn Thư* [The Complete Book of the Historical Records of Đại Việt], show that the thirteenth and fourteenth centuries was an extremely wet period. The Red River dike system fully came into being in this period of climate change. In 1248, the Vietnamese rulers ordered their people to construct the Đỉnh Nhĩ (lit., 'cauldron handle') dikes 'from the beginning of each river to the seacoast to ward off the floods.' Although the original techniques for building these dikes remain unknown, their name apparently came from the idea that they had a curved shape like the handle of a cauldron (Fig. 2). The cauldron handle dikes and the socio-political system embedded in them had a lengthy impact on the interaction between the Vietnamese people and the Red River delta. A regulation issued in 1434, for instance, allowed sons and grandsons of officials ranked from the sixth echelon upward to be exempt from general taxes and all types of forced labour, except for duties relating to the construction of the cauldron handle dikes.

Throughout the periods before the twentieth century, dike works helped sustain two major traditions. First, the purpose of dike repairs and new constructions continued targeting the protection of crops. As floodwater was both a natural hazard and important for growing wet rice – a significant crop in the Red River Delta – regular maintenance of dikes and sluices was woven into local people's annual agricultural rhythm. Second, dike works were deeply integrated into the social life of inhabitants. As dike works were considered as an annual public duty, many farmers alternated as dike builders. A sustained taxonomy of dikes, which remained evident until the late nineteenth century, differentiated public dikes from those in private ownership. This differentiation indicated whether financial and human resources would be the responsibility of the central state or that of local villages. Hence, dike works tapped into political duties and economic resources at all levels, from the state to many individual famers.



略 築堤 1248

戊申十七年宋淳祐八年春正月改徽宗廟號曰太祖廟壽陵曰徽陵○三月令諸路築堤防水名曰鼎耳自源頭至海岸以遏洪水漲溢置河提正副使管督之所築之處視民田地度其所築依價還錢鼎耳之築自此始○夏四月造臨波橋於真教禪寺跨玩蟾池抵景灵宮大清觀極其奢麗○六月順天皇后崩追尊顯慈順天皇太后○遣風水者遍觀天下山川有王氣之處用方術厭勝之如清化鑿婆醴江椎昭舶山之類其塞溪港開阡陌不可殫紀從陳守度之言也

Fig. 2: An excerpt on the construction of the cauldron-handle dikes in 1248. *Source: Lê Văn Hưu, Phan Phu Tiên, Ngô Sĩ Liên, et al., Đại Việt sử ký toàn thư 大越史記全書 [The complete book of the historical records of Đại Việt], Paris. SA. PD. 2310, Bản kỷ 5, pp. 15b–16a.*

The age-old Red River dike system has evolved into a network of embankments, sluices, and channels, to regulate water flow across this delta. Today, Vietnam maintains a complex, often confusing, administrative structure to oversee dike works. A constituent unit of the Office of the Steering Committee for Natural Disaster Prevention and Control, the Office of Dike Management (Vietnamese: *Vụ Quản lý Đê điều*) is a specialised agency of the central government that has been operating since 2017. In parallel with this, the central government has additionally appointed local agencies for dike works. Further, information of dike management may be within the mandate of Directorate of Water Resources or other organisations working on environmental issues. An understanding of these dikes as historical and cultural heritage remains non-existent.

Fig. 3: 'làng tôi@ đê sông Hồng' [A village on the Red River dikes]. *© Nguyen Vu Hung, 2012 Flickr user / photographer (https://www.flickr.com/people/vuhung).*

In addition to governmental management of data as an impediment for public access to information on dike works, the interplay between the Red River dikes and many northern Vietnamese people persists. For those who have lived along these dikes, the specific sections of the dikes that run past their settlements symbolise a cultural icon of their villages (Fig. 3). The dikes have often served as roads connecting neighbouring villages and public places for communal demonstrations (Fig. 4). They have also entered songs and literature as an inherent element of the northern Vietnamese landscape.

Case study 3: Water culture heritage in the Vietnamese Mekong River Delta

Le Anh Tuan, Can Tho University, Vietnam

Introduction

The Mekong River Delta in Vietnam (VMD), the farthest downstream part of the Mekong River Basin, is an area of young geological origin formed by alluvial deposits from the Mekong River. The delta receives large quantities of annual water from upstream flow before entering the East Sea and the Gulf of Thailand (Fig. 1). The delta is low lying and flat, with an average elevation of about 1.00–1.50 metres above mean sea level. The VMD covers over 4 million hectares and hosts around 18 million inhabitants. Historically and practically, the people of the delta have settled in high density along the river and canal banks. Water supporting human life, agriculture and aquaculture production, domestic supplies in the delta depends largely on the meteorological and hydrological regime. The presence of water has transformed the VMD into one of the largest wetlands supporting large-scale agriculture and aquaculture production in Vietnam. The region is highly productive thanks to abundant water resources with alluvium in large scale and a complex irrigation canal system of the Mekong River. Each year, the delta supplies more than 50 per cent of the nation's staple rice and food crop, 80 per cent of the total fish production, and 75 per cent of tree fruits for domestic use and export (Tuan, 2017).

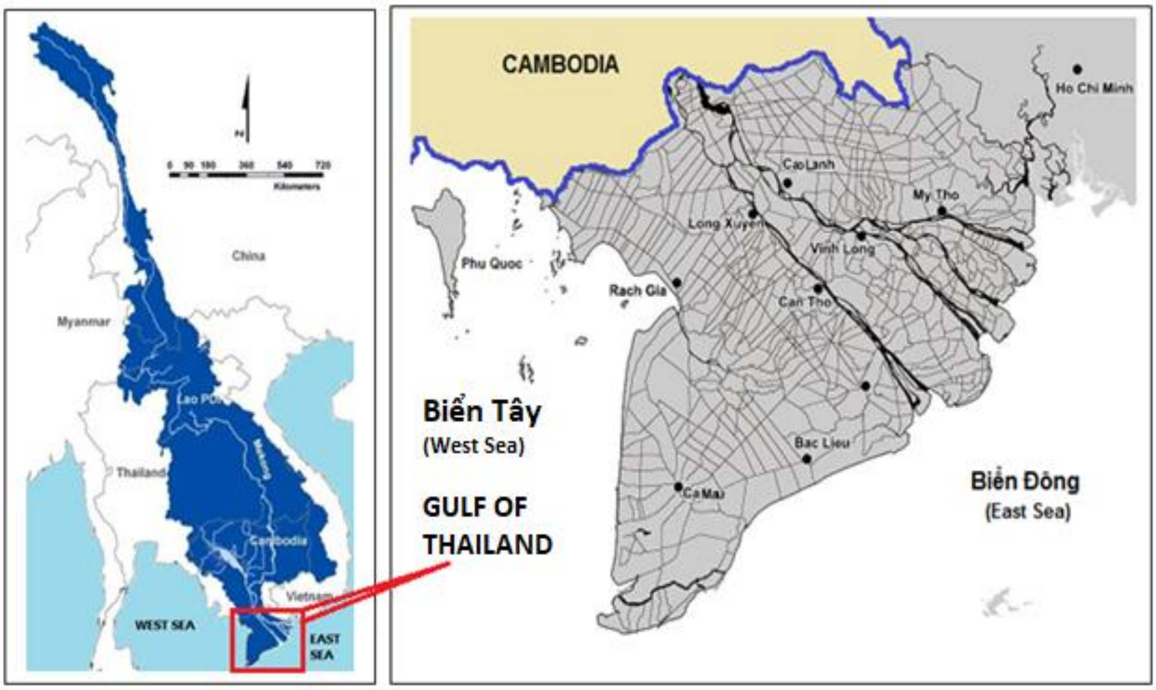


Fig. 1: Maps of the Mekong Basin and the Vietnamese Mekong River Basin. © *Source: Benedikter, 2014, with modified and added.*

Expectations related to increased food production and uncontrolled urbanisation and industrialisation may be a real challenge for the delta's water environment in the near future. In addition, climate change and transboundary water problems are other potential threats to environmental sustainability as more than 85 per cent of the VMD's water resources originate from other countries (Tuan, 2017).

1. Water as part of Vietnamese Mekong Delta cultural heritage

Vietnam is perhaps the only country in the world, where the word '*water*' has the same meaning referring to a nation or country as well as indicating the element H_2O, combining one oxygen atom and two hydrogen atoms producing a resource precious for life, present in the earth's hydrosphere. In the cultural quintessence of Vietnam, the country is attached to the lifeline of each person through its history. Vietnamese people use the phrase ‘to keep the water’ (which means protect the country/nation in Vietnamese) when defending against foreign invasion in the northern country and use the phrase ‘to open the water’ (instead of stating to open the land) when extending the country’s border to the South. Vietnamese people, from past to present, have a custom of migrating and settling around and cultivating in water-intensive areas such as rivers, streams, lakes, lagoons, and coasts. The gathering of communities for social, cultural, historical, and spiritual activities are all connected to a water source. Therefore, in the history of national development, water resource governance has also been part of the national and community administrative structure. Spiritually as well, on the worshiping table of Heaven and Earth and Ancestors, Vietnamese people usually put two cups of clean water as a form of ritual.

Fig. 2: Water jars are put outdoors for any pedestrian who needs water to drink as a culture of sharing clean water, 2006. © *Le Anh Tuan*

Nowhere else in Vietnam, are local words related to water resources richer than at the Mekong Delta – words such as main rivers, branch rivers, waterways, river mouths, canals, ditches, wetlands, lowlands, ponds, trenches, floodplains, lagoons, river mounds, tops, ramps, bays, berms, islets, islands, estuaries. Based on the water flow characteristics, people have names: high flood water, low flood water, high tidal water, low tidal water, floating water, flood water, low water, silver water, reddish water. Regarding water supply and quality, there are words: heaven water, rainwater, river water, well water, groundwater, stagnated water, fresh water, brackish water, salty water, alum water, acid water, peat water. In the VMD, the combination of water terminals, floating markets and villages is the most obvious characteristic of the population and their livelihoods.

Since ancient times, Vietnamese communities have had rules, customs, behaviours, ethics related to sharing water from village ponds, wells, or public water tanks in rural, mountainous areas throughout the region from north to south. In VMD, if you are thirsty on the road, you can naturally drop by any house to drink water from the alley without asking the owner's permission (see Fig. 2). If you happen to meet the host who is eating, you may be naturally invited to eat without formality. People with inner fields can negotiate with the owner of the outside field to cut a ditch that brings water from rivers and canals to their fields without having to buy land to dig ditches. During the rice harvest season, the underprivileged can ask to harvest rice from the

Fig. 3: The poor can catch fish freely anywhere in the VMD flood seasons, 2011 © *Le Anh Tuan.*

field or raise ducks to run into each field to eat rice, snails, or vegetables. During the Mekong flooding season in the Long Xuyen Quadrangle and in the Plain of Reeds, one can catch fish anywhere in a vast water field with the concept of 'The land is private, but nature's fish belong to the public'... At that time, the boundary of the fields is completely submerged in flood waters and so those in need could go by boat to fish freely without any restriction (see Fig. 3). The concept of sharing water resources is like an unwritten convention for this water region.

2. Water resource challenges facing Vietnamese Mekong Delta

Currently, the VMD is facing serious environmental challenges and climate change. Evidence over the last two or three decades shows an increase in the average air temperature in the entire delta, with a decrease in rainfall in the early season and increase at the end of the wet season. The recorded average water level tends to rise while salinity intrusion is increasing combined with droughts in the dry season leading to serious challenges related to water supply and cultivation. It is anticipated that approximately one-third of the delta would be inundated with a 1.0m sea level rise as predicted by the next century, even as early as the year 2100 in the worst scenario (Carew-Reid, 2007). It is estimated that by the 2050s, as many as one to five million people will be at risk of being displaced. Presently, erosion of the coastal banks and other abnormal weather phenomena seem more serious in their impact on many local ecosystems and residential lands. Concerning the long-term sustainable development of the MD, the food – water – energy nexus should play a pivotal role for finding adaptive solutions at a regional and local level. Minimising the impact of human activities on the water environment also ensures sustainable development of the MD (Trieu *et al.*, 2007).

Water resources in the VMD face greater challenges due to increased threat from climate change and sea level rise, expansion of cultivated areas and trans-boundary water-related problems. Dam development for hydropower and irrigation, in main and tributary streams seem a priority in the Upper River landscapes for serving energy and water demands. However, the operation of the dam-reservoir-hydropower systems may create adverse impacts on environmental flows and ecosystems. Reservoirs for hydropower in the upper Mekong River store as well as regulate much of the water in the downstream, challenging agricultural cultivation, water supply for domestic use and saltwater intrusion from the East Sea. So, the Lower Mekong River Regions have to deal with serious threats and double impacts, addressing both climate change and consequences of upstream dams. Projected climate, industrial development, operation of upstream hydropower dams could alone, or in combination, increase many negative effects on local rice and fish cultivation in the delta.

Conclusion

Water, land, and climate are the three most important resources / factors affecting the development and survival of natural ecosystems and production in the delta in the past centuries. To address current and future challenges, there must be collaboration between government authorities, scientists, natural resources, environmental management agencies and local communities. Appropriate coping measures for weather variations and for integrating climate change into local socio-economic development plans have a great significance for the VMD. Currently, national adaptation strategies focus on short-term mitigation measures in emergencies, awareness raising activities and the establishment of climate change adaptation action plans. There is an urgent need to find solutions for climate change adaptation combined with integrated management of water resources to ensure a long-term foundation for sustainable development of the Vietnamese Mekong River Delta.

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11. Cambodia

Regional overview: The outstanding legacy of water management from the Angkor Civilisation Period

By Michel Cotte, University of Nantes (France) and ICOMOS Adviser

In this paper we do not intend to make a complete and precise survey of today's heritage of water management in Cambodia, or to offer updated indications about protection and conservation related to it. We modestly aim to indicate the composition of the exceptional heritage of the Khmer civilisation in the field of water management through some typological indication and illustration through significant examples. It is evident that the extraordinary built complex of **Angkor** offers a range of remarkable water management devices, though the site is mainly recognised and visited (by millions of tourists fromall over the world) for its incredible series of amazing temples and associated constructions. The site was nominated on the World heritage List from 1992 with criteria (i) (ii) (iii) and (iv). UNESCO has set up a wide-ranging programme to safeguard this symbolic site and its surroundings. Also on the List is the capital of the first Khmer kingdom, **Sambor Prei Kuk**, which in Khmer language translates to 'the temple in the richness of the forest'. This was listed in 2017 using criteria (ii) (iii) and (iv), mainly for its architectural, decorative, and urban attributes, though it included noticeable hydraulic features. The temple of Preah Vihear on the northern boundary of Cambodia is also on the World heritage List, but its mountainous location may be responsible for an absence of significant hydraulic heritage.

1. Geographic and climatic context, the role of Tonle Sap Lake

Fig. 1: Rural landscape near Sean Reap in the present time – Cambodia. © *Michel Cotte.*

The ancient civilisations of South-Eastern Asia relied strongly on wet rice production and the associated use of natural water from rainfall and river flow. Cambodia presents a large amount of interior alluvial plains and low hills adapted for this agricultural production. This farming practice is favoured by an appropriate tropical climate with alternative rainy monsoons and dry seasons of similar duration. The thermic amplitude is limited, and temperature remains similar throughout the year through wet and dry seasons to around 25 degrees Celsius. Maximum picks are undertaken just before the spring monsoon and minimum during winter. The Indo-Chinese Mountain ridge generally protects the central plain of Cambodia from Pacific typhoons.

Wet rice agriculture has shaped central Cambodia landscapes since ancient times, especially in the Tonle Sap basin and the plain of the lower Mekong River. An extremely specific hydraulic phenomenon is the reverse flow from the Mekong to Tonle Sape Lake through the Tonle Sap River. This junction point corresponds with the establishment of the city of Phnom-Pen. During the dry season (end of winter, beginning of spring), the Tonle Sap River plays the usual role of a tributary of the Mekong River; but the low level of the lake produces an inversion of the flow during the two wet seasons, the first at the end of spring and summer, the second at the end of autumn and early winter. The periodical Tonle Sap flooding involves an incredibly significant surface. The lake enlarges from 2,700 km^2 to around 25,000 km^2; its average depth grows from 1 metre to 9 metres. Generally, and due to the geography of the region, inundations by rivers are frequent, regular and dealt with in large territorial zones. These repetitive phenomena produce large predicable inundations in central Cambodia and may also be seen in the neighbouring and similar landscapes of Laos and Thailand.

2. The early development of 'rice civilisation' in the Cambodia region

This situation of seasonal inundations around Tonle Sap, lower Mekong River and all along their tributaries corresponds to a large hydraulic basin made of interior alluvial plains and low hilly regions. It offered a favourable situation for early development of wet rice crops by humans with some abilities to understand and work with natural hydraulic processes to retain sufficient water in shallow flooded zones and to guide excess flow etc.

With such competence, it was relatively simple to harvest twice a year and even thrice with appropriate water management. Starting with the use of natural flooded zones and progressively extending with the regulation of water, the development of wet rice production is very old in the region, coming from proto history. These techniques have reciprocal influences both with China and India. These efforts forged typical rice field landscapes which were long lasting; systems that needed to remain dynamic to continue in existence, working in tandem with regular use and hydraulic management. This helped to work against the taking over of the tropical forest which easily regains its right to the landscape once regular human action ceases.

Initially, the most favourable zones were limited to those with reasonable in-depth natural flooding but progressively spread to larger zones through improvement of hydraulic techniques. They mainly relied on gravity leading to a controlled movement of water and on the art of water storage for dry seasons. Every technique used local material, mainly crude earth with enough clay content for the waterproofing of dikes and wood for water control devices. In any case, the maintenance of the basic efficiency of water techniques remained difficult because of the intensity of natural threats such as exceptional floods or severe dry seasons. Regular disasters and rebuilding were a regular necessity. The low-lying zones of flooding plains remained uninhabitable and too wet for regular agricultural use and the plateaus, or some plateau zones remained frequently too dry to be regularly productive.

Nevertheless, the long and ancient sustainable agrarian development by controlled flooding in these regions allowed an early demographic increase, especially favourable to urban development as seen in other ancient rural civilisations, from the Nile and Mesopotamia to China. As population increased the hydraulic works extended their scope to address domestic needs, protection against floods, regulating rivers, transportation and to the intangible, religious and symbolic meanings related to temples, palaces, and water systems.

During an early period of development, approximately from the second to seventh centuries AD, rural use, and water management progressively remodelled territories in the most favourable zones of the region. Archaeologist, Bernard-Philippe Groslier (1974 and 1979) indicates two main origins of rural hydraulic traditions in that period. The first resulted from an affirmation of the rural and commercial kingdom of Fou-nan, under Indian influence, along the seashore including the Mekong Delta. It included notable development of rice fields, digging canals for land reclamation and drainage in the delta or low plains, and building dams in surrounding hilly areas. The second was led by the direct ancestors of Khmers inside the territory of the middle Mekong River, surrounding plains and low hilly countries or plateaus, e.g. the Se Mun Valley and the Champassak region. This probably signified early attempts by Khmers, during the seventh century at building the first noticeable reservoirs with surrounding moats supplied by rivers.

The specialists of rural development J. E. Spencer and Ch. Taillard (1974) proposed a summary of the situation of 'ancient traditional water management' in South-Eastern Asia relying on the following categories: 1) natural flooded regions, 2) dams and associated canals, 3) reservoirs and 4) protection dike systems. The data remains general and expansive without precise references but offers an extension of the joint phenomenon of geo-climatic conditions and ancient human adaptation by appropriate hydraulic techniques.

Fig. 2: The natural flooded regions and current traditional hydraulic technics in South-Eastern Asia, after Spencer J. E. and Taillard Christian, *Études rurales*, n°53-56, Paris, EHESS, 1974, p. 76.

3. Initial techniques of Khmer hydraulic management: Water in the city

3.1. Sambor Prei Kuk (seventh century)

A synthesis between the two hydraulic traditions occurred when the first real Khmer kingdom, the Chenian Empire arose post conquest of Fou-nan, at the end of the sixth century. A new capital Sambor

Prei Kuk Khmer emerged from this expansion through materialisation of new hydraulic standards for urban use, hydraulic regulation, defence, transportation, and irrigation but also to establish new symbolic meanings.

The development of the city benefited from the abundant water resources in its environment. A ring canal, 15 metres wide and 2-3 metres in depth surrounded the city itself, supplied by a river derivation. This was connected to an outlet drainage canal that joined the downstream of the river. The city was also equipped with large reservoirs reinforced by artificial dikes and moats to supply the city and its surroundings. Canals and rivers offered an inland navigation network for goods' transportation. Nevertheless, the exact function of each tangible attribute and their relationships are not known with certitude and thus require further archaeological research.

The surrounding valleys and foothills were managed by a series of smaller dams to catch and retain water to irrigate a succession of rice fields for intensive production. Such richness supported the power of the first Khmer Empire, exemplified by an exceptional set of monuments and decorations of Sambor Prei Kuk, not seen in the Indo-chinese peninsula at the time. Hydraulic management led to the creation of a large-scale, sophisticated and diversified, engineered hydraulic system, certainly the oldest one of such complexity in South-Eastern Asia, predating the *baray* system of Angkor. Unfortunately, only fragments of this system survive. Built mainly during the early seventh century, Sambor Prei Kuk ensemble preceded and led to the significant urban, religious complexes of Borobudur (Indonesia) and Angkor, its direct descendants some centuries later.

Fig. 3: Srah Smach, ancient pond inside protection zone 1 of Sambor Prei Kuk site. © *Nomination file - Temple Zone of Sambor Prei Kuk, Archaeological Site of Ancient Ishanapura.*

The end of the seventh century and the eighth century were periods of political confusion with a rapid decline of Sambor Prei Kuk as the capital city. It appears that agricultural techniques relying on hydraulic expertise were being widely used in all the Khmer countries. Every city, even smaller ones, established an artificial pond supplied by a river or nearby springs to ensure that favourable soils were equipped for irrigation and production of rice crops. Many Khmer inscriptions of that time were devoted to construction of a dike or a water body in proximity to a temple. Nevertheless, economic development remained limited to local communities. Hydraulic capacities remained relatively low, facing the challenges of natural context and necessary maintenance. Average production seems reduced at the time to an auto-sufficient level.

Natural conditions of Cambodia inland are not favourable although its tropical climate with two monsoons and sufficient rainwater for a third of the year suggest otherwise. The soil is generally poor, made of alluvial sand with clay earth. This remains fragile due to deforestation. The dry season is hot and severe. The use of natural water reserves from Mekong or Tonle Sap Lake was exceedingly difficult to implement. Local rivers are capricious, oscillating between destructive floods and exceptionally low water and are technically difficult to control. In other words: 'it is too much water in too short time'. To face these challenges required important actions and resources, on a large scale, managed by a powerful central government.

3.2. The ancient city of Hariharâlaya, prefiguration of future Angkor (ninth century)

The Siem Reap region was one of the most favourable for human settlement in hinterland Cambodia. A rich alluvial constitution in proximity of Tonle Sap Lake and proximity to abundant rivers from the Kulen sandstone plateau, formed a natural water reservoir. Archaeological traces of protohistoric periods have been discovered not far from the upper side of Tonle Sap Lake. During the seventh century it was a rural zone occupied by Khmer people residing in a medium-sized main city: Ak Yum. It had a defensive water ring modelled on the lines of Sambor. During the eighth century and early ninth century the growth of the local population reinforced its central position when the Khmer dynasty regained power.

The capital city of **Hariharâlaya**, close to Tonle Sap Lake, was conceived by Jayavarman II (reign: 802–830), the first important Khmer king in the Siem Reap region. The construction and birth of a completely new city design established a fundamental link between water management for agriculture with symbolic attributes of power and religion. This was further developed by its successors, especially king Indravarman (reign: 877–889). The key to the system was the first large-scale artificial pond (or *baray*); it was implemented during the second half of the ninth century with the simultaneous development of temples and an irrigation system for rice fields. The *baray* stored water issued from the Roluos River coming down from the Kulen plateau. The original surface of the *baray* extended across 300 hectares for water storage of 10 million cubic metres multiplying the capacity of traditional village ponds 100 times. The main *baray* (Lolei) was oriented east-west and it formed the 'city' in association with a monumental ensemble of temples, oriented north-south toward the Tonle Sap. The Bakong is the most important, completed by a series of later constructions. Bakong benefited from a large square ring of moats, with ritual and aesthetic roles. The irrigation system was supplied by the *baray* and associated reservoirs through an important feeder canal for distribution. Such an ensemble was the first of this type in the Angkor region.

Complementing the main *baray*, aerial photos show a set of eight, square, equal water basins of 60-metre sides regularly seen along defence walls and on the outside. A protective water moat outlines the ensemble, combining hydraulic management, symbolic meaning, and aesthetic purposes. The *baray* and its associated reservoirs caught rain fall and surplus from the Roluos River. This allowed gravity irrigation for a large ribbon of lowlands situated between the city and the Tonle Sap side. The irrigation system used the natural bed of small local streams with additional connections. According to Groslier (1974), this use resulted in more than 5,000 hectares of irrigated agriculture.

4. The hydraulic concept of the Khmer city

4.1. The first Angkor urban and irrigation settlement (tenth century and early eleventh century)

The emergence of the complex of Angkor itself started at the end of the ninth and early tenth century, when King Yasovarman (889–910) decided to create a completely new capital following the model of the 'hydraulic city' and to develop a new set of irrigated rice fields. He chose a place higher to the initial Hariharâlaya, between the Roluos River and the medium course of the Siem Reap River. He built the Bakhêng Temple followed a few years later by the exceptionally large Angkor *baray,* later called the **Eastern *baray***. Of rectangular form and oriented east-west, like the Lolei model, but of larger dimensions – more than 7.1 km long and 1.7 km wide – its water capacity was around 50 million cubic metres, six times the volume of its model. With an associated feeder canal from the Siem Reap River and the Ruluos River the irrigation area in the low valley added to the former one from Hariharâlaya. This was what the French archaeologist Groslier (1979) named the 'Hydraulic City' of Angkor. This first foundation of Angkor remains renowned in the history of the city. This illustrated a peaceful and positive management of nature for human benefit, referred to in European Renaissance as the image of a 'bon government'.

The water supply of the *baray* was contributed to by different sources because enormous needs were to be fulfilled, which required appropriate feeder canals and hydraulic captures or derivation on upper rivers and streams. We have some archaeological evidence to understand how this hydraulic system operated. Nevertheless, diverse important modifications and addition over time make this task difficult. The irrigation was carried out by gravity and water ran slowly from one rice trap to the next. Interconnection with the ancient Hariharâlaya irrigation zone seems probable with possibility of mutual water transfers.

The *baray* was not directly in line with the temple of Bakhêng, as was evident later, probably for geophysical and hydrological reasons, but it was in proximity. The temple itself had a position on a little natural elevation around which was built an important square water ring. Even though the exact hydraulic operating mode of the whole is not completely demonstrated, and the precise extension of irrigated rice fields is not evident, the enormity of hydraulic works and their interconnections at large scale are certain.

Successors of Yasovarman, especially Râjendravarman (944–968) and Jayavarman V (968–1001) reused the initial city of Angkor and completed it by adding magnificent temples such as the Mebon, at the centre of the *baray*, the Pré Rup with its square water ring on the southern axis or later the premises of the future Royal City on the western part of the main *baray* axis, with sophisticated water supply of interior moats by siphon from the *baray*.

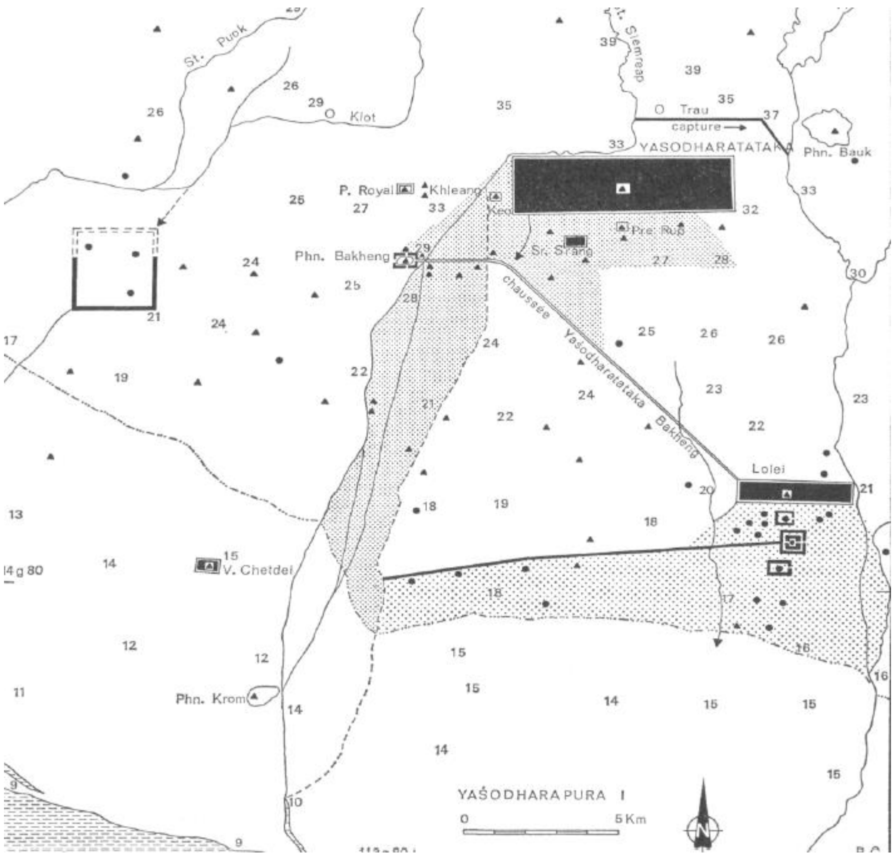

Fig. 4: The first 'hydraulic city' of Angkor and its hydraulic connection with Hariharâlaya, after Groslier B. P., *Bulletin de l'Ecole française d'Extrême-Orient*, 1979, p. 198.

4.2. The technical requirements of the Khmer 'hydraulic city'

The central purpose aimed to develop permanent irrigation for large expanses of agriculture to produce regular and abundant crops, especially for wet rice harvests twice a year and even an additional crop of diverse vegetables or grains to ensure the sustainable economic and political power of the Khmer kingdom. From this initial model offering a new type of territorial management for tropical zones, the development and regional supremacy of the Khmer Empire had been launched.

Over the following years, the implementation and successive improvements or modification of the Angkor initial hydraulic system moulded into a complex history, making it difficult for archaeologists to understand both real successive works and the exact functions of exhausted structures and findings.

The main idea of water regulation on a grand scale used the most favourable sites for water storage. The system relied on collecting and keeping a large amount of water during the monsoon and releasing it during the dry season, mainly for agriculture and urban domestic supply. Water gathering operated on the upper lands of the city. The natural river system with appropriate deviation canals conveyed excess water toward the artificial *barays* inside or close to the city. Beyond serving as a reservoir, this system was relevant in flood prevention, protecting the city through a large system of dikes and artificial ponds as controlled flood expansion area.

The efficiency of water storage demanded a series of strict technical construction standards:

- To choose an appropriate location for *barays* to ensure:
- Easy water supply from rainfall and natural river network but protection from direct flooding,
- A favourable upper position related to irrigated lands and
- An appropriate soil with the clay layer close to the surface;
- The *Baray* is not a dug reservoir, but a surface reservoir with important earth dikes; which allows natural water management by gravity without any technical device; earth for dikes was provided by lateral moats both inside and outside the reservoir;
- To design sufficiently large *barays* to keep a significant volume of water for land irrigation all through the dry season. The *baray* may be completed using additional reserves from diverse moats around temples and medium or little surface reservoirs; the shapes were almost systematically square or rectangular;
- Dikes must be sufficiently high to reach a minimum *baray* depth (more than 1.5 metres), which limits the natural intense evaporation during the dry and hot sunny season. The *baray* must be permanently filled with water and never left dry;
- To control and limit the sedimentation inside *barays* and all along the hydraulic system by appropriate maintenance;

The final step of the process consisted of managing the water distribution through a large network of urban canals and a rural irrigation system, which started from the external moat of the *baray*, permanently supplied by the infiltration of water through the dike. Irrigation was conducted by gravity, using a natural network of little rivers and streams. Human intervention for downstream infrastructure was limited to connecting the different natural hydraulic components aimed at making a centrally controlled system, and to manage the succession of irrigation traps. The *baray* ensemble and the whole associated urban hydraulic implementation are a remarkable part of the Angkor heritage today. It remains a highly impressive work which required significant human resources and exceptional civil engineering capabilities. This urban importance is signified by substantial remains and the legacy of a water system inside the city, but more poorly for the heritage beyond the extents. Though certain irrigation uses related to the vestiges of some ancient grand *barays* continue, they are generally abandoned with the jungle reappropriating its rights as is frequently the case for temples.

Nevertheless, there are some divergences between experts relating to the interpretation and real use of the hydraulic ensemble during the Khmer period. The understanding of archaeological remains and facts is not totally consensual, even contesting the purposes of the 'hydraulic city' itself. Briefly and very schematically: initial schools of thought promoted that the irrigation goal and hydraulic annual regulation was the first and most preponderant, with later symbolic and religious additional value with architectural and urban influence. Critics, however, propose a reverse of causalities: the *baray* system and its emphasis were mainly related to expression of the political power and religious beliefs playing a decisive role in urban planning, reiterating that the irrigation function appears as not totally demonstrated in the landscape. Additional research is clearly required on the hydraulic system of the initial Khmer period, with perhaps new tools such as a systematic Lidar survey for a better territorial understanding.

5. The main successive periods of hydraulic construction at Angkor

The Angkor landscape was therefore favourable for the implementation of water management on a large scale, and its associated uses for citizens and irrigation. This was well demonstrated by two successive attempts of Hariharâlaya and the first Angkor city around its large *baray*. These needs and requirements determined the location of the capital city, at the core of which was the hydraulic system and its management. An urban location and political and religious constructions within it all relied upon this cultural pattern. These features of the Khmer civilisation led to close relationships between temples and reference masterpieces of the water system represented by the successive *barays*. For instance, the main axis of *barays* was generally east-west, in direct correlation with the location of the associated temple, on the western part of the axis or eventually on the orthogonal axis for the oldest examples. There was a cosmological correspondence and expression of harmony between temples and the water surface, as it was for celestial bodies in the sky. The city was based on a concept where the power of the king commanded the main location related both to divinity and to the mastering of water. Each king aimed to create their own city showing their personal role in accordance with cosmos and in line with gods.

Throughout the tenth and early eleventh centuries, the hydraulic equipment of the Angkor region was completed, using almost all the rivers for their water resource, and supporting an efficient economic pattern which reinforced the political legitimacy of the dynasty. Successive kings constructed temples and progressively modified the Angkor panorama, but the hydraulic system remained similar over more than a century. There were punctual improvements or extensions of capacities and establishing territorial water rings associated with new temples through setting up additional reservoirs. This period was also oriented toward regional extension of Khmer settlements, by replication of the model of an artificial pound associated with a temple and irrigated rice fields. Khmers as a result built a long linear 'dike ways' serving both for flow control and for non-flooded ways of communication between settlements. This served as a route of development lined with villages and houses along it.

5.1. The gigantic Western *Baray* (eleventh century)

In the middle of the eleventh century, a new and radical extension of the city and its water capacity was designed and launched by a succession of kings leading up to the famous reign of Jayavarman VII (1080–1107). This constitutes what Groslier named the second hydraulic city of Angkor. For water management, the key issue was the edification of the **Western Baray**. It was the apogee of the hydraulic achievement of the Angkor region. The rectangular dimensions of the *baray* were around 8 x 2.1 km with a water capacity for irrigation of around 60 million cubic metres; which allowed at least 70,000 hectares of wet rice fields in Angkor, with probably two crops a year and some interludes with complementary vegetables (Groslier, 1974).

The Seam Reap River and the O Klot River supplied the new *baray* by way of canals and by the full diking of the O Klot to control its floods. This was completed by a temple named Western Mebon, at the centre of the *baray*, which expressed hydraulic attributes related to religious beliefs especially through an internal sacred pool. One of the most popular myths of the Khmer people was related to the image of 'Water Mother' descending from sky to earth with fertilisation powers. The Temple of Baphuong, east of the new *baray* accompanied this gigantic constructive programme. Located on the exact axis of the ancient eastern *baray* this made a symbolic link between the two artificial ponds. A canal repartitioned the water, going along the contour line and joining the former irrigation area. After some works were undertaken during the twentieth century for rural reuse including with some Limon deposit, the Western *Baray* continues to function as a reservoir.

This was also a period for reinforcing and extending irrigation settlements in the region, especially by the extension of the network of long and large dikes both for controlling water run-off and as ways of communication.

Fig. 5: Aerial view of the Western Baray with its rectangular dikes and water ring canal; it still serves as a reservoir; in the centre, the Western Mebon Temple; at the east, the Baphuong Temple is involved inside the 'Royal City' complex (Angkor Thom) constructed later. © *Google maps, 2020.*

5.2. The Angkor Vat period (twelfth century)

The **Angkor Vat** temple was dedicated to the Hindu deity, Vishnu and is considered the masterpiece of King Sûryavarman II (1113–1150). This included important hydraulic attributes surrounding the temple. For instance, the square ring of water at Angkor Vat has a perimeter of 5.5 km with a width of 200 metres, and two banks facing with regular slopes made of chipped stones with a water capacity reaching 5 million cubic metres. This offers a monumental and perfect aesthetic reflection of the temple, one of the most admired in the world. At the time, the enormous amount of work involved in this hydraulic engineering seems to have been mainly devoted to religious monumentalism and creation of a highly aesthetic 'landscape with water'. In this view, the result is extremely impressive with water attributes contributing in large measure to the expected visual effect.

Angkor Vat offers, both for the Khmer people of the time and for visitors today, an unforgotten experience of the multidimensional importance of water in human life, from practical use as the basis of the sustainable life of humans to religious meanings and a unique aesthetic value. This is expressed by the peaceful water surface as a perfect natural element in combination with an outstanding central architecture made by humans. It provides a transcendental feeling of a harmonious relationship of human intelligence and providential nature.

Though irrigation and water supply for practical use relied on the existing hydraulic network, especially the existing *baray*s, both for supplying the water ring and to contribute to the reserve capacity for dry seasons, this was not decisive. Angkor Vat could not be considered as a totally renewed hydraulic design as were the former examples that drastically changed the scale and extension of the irrigation surfaces. This could be considered at best, a notable improvement of existing regulation capacity and with some limited extension of irrigation surface. It is possible that at that time tan important *baray* project was planned but abandoned. This period should be seen both as an apogee for useful hydraulics especially for irrigation, and the first serious meeting of technical limits. New rice field zones became more difficult to irrigate; unexploited water resources were scarcer, and excess of sandy limon had reached maximum maintenance capacities.

Nevertheless, this remark is valid only for the Angkor region, which reached maximum capacities and where additional hydraulic development seemed both difficult and expansive. The initial richness of the Khmer central power and the former well demonstrated how the efficiency of its development model relied on the concept of' hydraulic city'. The period is remarkable for the diffusion of the model to other river basins and important large-scale implementations, e. g. at Beng Mealea, Preah Khan, etc. (see section 7).

Fig. 6: An Angkor Vat monumental access way and its square water ring in 2013. © *Michel Cotte.*

5.3. The intense revival period during the reign of Jayavarman VII (turn of the twelfth/thirteenth centuries)

Despite its extension and increasing regional influence relying on the development model of the ‘hydraulic city’ or resulting from the Khmer richness and its territorial ambition, the end of the twelfth century was a regressive period due to a foreign military attack by the Cham kingdom and to a relative political decline of Khmer central power. On ending the Cham conquest, the revival was prompt, mainly during the reign of Jayavarman VII (1181–1219). His long reign resulted in multiple revivals related to Khmer society and culture: material for architecture and urban planning, and spiritual upliftment by the advent of Buddhist worship. At the time, notable hydraulic projects helped restore and reinforce Khmer power which were intricately linked with other aspects of Khmer revival. These were expressed with a notable munificence and high aesthetic creativity. Despite having probably reached its limits for rice crop production and rural resources by way of irrigation, the Angkor area remained pivotal for Khmer power at the turn of the twelfth/thirteenth centuries, expressed through a series of major projects.

The royal palace of **Angkor Thom** was built mainly by Jayavarman VII, one of the most emblematic kings of Khmer. Angkor Thom was the most complex and diverse ensemble ever achieved in Angkor, involving anterior temples, and continued by successors of Jayavarman VII. This ensemble was perfectly organised inside a large square within defence walls and orthogonal access ways with monumental gates. At that time, it was impossible to find vacant space within the Angkor region, either for an appropriate extension of the existing water management system or for the implementation of a completely new city design with respect to existing cosmological orientation. This was done in the vicinity of former temples and *barays*, implying innovative and ingenious solutions for hydraulic facilities aiming to connect and complete the existing water network, especially through its square water ring in the traditional manner. Angkor Thom is frequently considered by its extension, its architectural diversity, its incredible number of exceptional sculptures and decorations as the masterpiece of Khmer civilisation with its close neighbour, Angkor Vat, thereby adding it to the water management history of the Khmer people and engineers.

Fig. 7: The Angkor Thom moat from the square water ring at one of the radial access gates of the royal city, in 2013. © *Michel Cotte.*

In hydraulic terms, Angkor Thom is mainly remarkable by its insertion in the existing system, especially in its location exactly between the two large *barays* already implemented, with associated symbolic value. What was certainly the most significant in the hydraulic revival was the implementation of a new *baray* associated with the Preah Khan Buddhist ensemble, located immediately north of the ancient eastern *baray*, which by that time had probably reduced in capacity due to sandy limon and a long period of ineffective management. The new reservoir named **Jayatataka Baray** was both a new reservoir adding water capacity of around 10 million cubic metres and a remarkable central monument, the **Neak Pean** temple at the exact centre of the new rectangular pond devoted to both, Buddhism, and water.

The hydraulic ensemble made of Jayatataka Baray and the moats of Angkor Thom seemingly did not serve to irrigate new fields and was devoted merely to reinforcing the existing system and to addressing the weaknesses that had appeared over time.

Fig. 8: The Jayatataka *Baray* and the Neak Pean Temple in 2013. © *Michel Cotte.*

5.4. The late Angkor period

Notable hydraulic works inside Angkor area were discontinued after the reign of Jayavarman VII. In the following period, from the thirteenth to the fifteenth century, the site of Angkor was the capital of a declining empire. The historian Groslier (1979) surmised that the origin of this decline was the result of a limitation of the hydraulic system and to its progressive alteration by sandy Limon; by degradation of the soil quality due to excessive and repetitive use; and by the impossibility to extend the water resource in the Angkor area. The irrigation by successive rice traps supplied by gravity was relatively fragile because the gradient was frequently negligible and sensitive to sandy Limon, which required important and regular maintenance work. Independent of political and social events inside Khmer society all through these centuries, the efficiency of the hydraulic system for irrigation slowly decreased with two main contradictory trends: (1) rice and vegetable production became more difficult with time, and (2) maintaining water capacity and distribution on a large scale required increasing maintenance works. This often resulted in clashes especially relating to the impossibility of maintaining a regime of three crops a year on sufficiently available land.

According to some observers, (Bruguier, 2000), a late irrigation period relying on a different hydraulic model existed. This was not centred on large *barays* associated with intensive agriculture but on the diffusion and extension of the long dike ways and bridge system, aiming to gather water at large scale with more limited periods of irrigation and less intensive production. This offered a different means of territory management and water use and may have been more an attempt to evolve and adapt to the situation with already existing techniques than a revolution. This allowed the Khmer civilisation to last for more than two centuries after its apogee. Dike ways combined a series of functions, both for military and civil transportation, for water management with their adaptation both for drainage and irrigation purposes. Bridges made of a series of small successive stone arches were key points within this large network; they were established for the transportation of people, animals, or goods, and for the control of water. For this purpose, the bridges were devoted to drainage during monsoon and reversely transformed into dams and locks for water regulation for irrigation when needed for agriculture. Bridges were also remarkable places for the implementation of notable religious or royal foundations and were marked by the presence of villages. Hundreds of kilometres of dike ways with adapted bridges existed in a large region all around Angkor and the different regions under Khmer control.

Fig. 9: Phra Phutthos, a Khmer bridge from the thirteenth century with corbel stone arches. © *Licence Structurae, ID 12993, JHM Cohen.*

6. The diffusion of a multifunctional model for water management

The achievement of successive versions of Angkor as a complete water management system constituted a model addressing both urban needs and irrigation requirements. This was replicated by the Khmer kingdom as a tool of power and colonisation, in the region that is Cambodia, Mekong medium basin and eastern Thailand today. These areas showcase diversified heritage representing different Khmer periods from the tenth to the fourteenth centuries. Some examples are briefly presented to showcase the diffusion of Khmer hydraulic concepts from different periods. This conveys important heritage facets for present-day visitors.

Fig. 10: A typical smaller temple in the Angkor region with its square water ring as reservoir and remains of stone slopes of its ancient, constructed banks, 2013. © *Michel Cotte.*

The **Phnomb Bakgêng** temple is a relatively early example of this phenomenon of replication. This was erected by King Yasovarman around 900 AD, some kilometres away from the present day Cambodian capital city of Phnom Penh. It was one of the largest Khmer temples not erected in association with a particularly important *baray* with feeder canal and irrigation system. Its dike construction required around 2 million cubic metres of earth.

Kor Ker, at around 80 km northeast of Angkor was constructed by the Khmer king Jayavarman IV (921–944 AD), who simultaneously attempted to transfer the capital while creating a new settlement inside a region that was relatively poor till then. This required setting up large-scale hydraulic works, e.g. important dikes to catch water and a large reservoir named Rahal associated with the temple. The main orientation of the religious complex and of the Rahal follows the axis of the valley, reflecting religious or cosmologic concerns, guided entirely by a geophysical pattern and aims of practical efficiency. Recent archaeological research shows the complexity of the place, even though it was built within a short time, with diverse secondary artificial ponds and numerus smaller circular ones, numbering more than 200 for the urban space. Very few of the different temples associated with medium ponds were surrounded by excavated moats as they were at Angkor. Kor Ker presents an interesting evolution of the initial model of the 'hydraulic city', with an ingenious adaptation to severe local conditions. It was an ephemeral capital of Jayavarman IV, who returned to Angkor before his death.

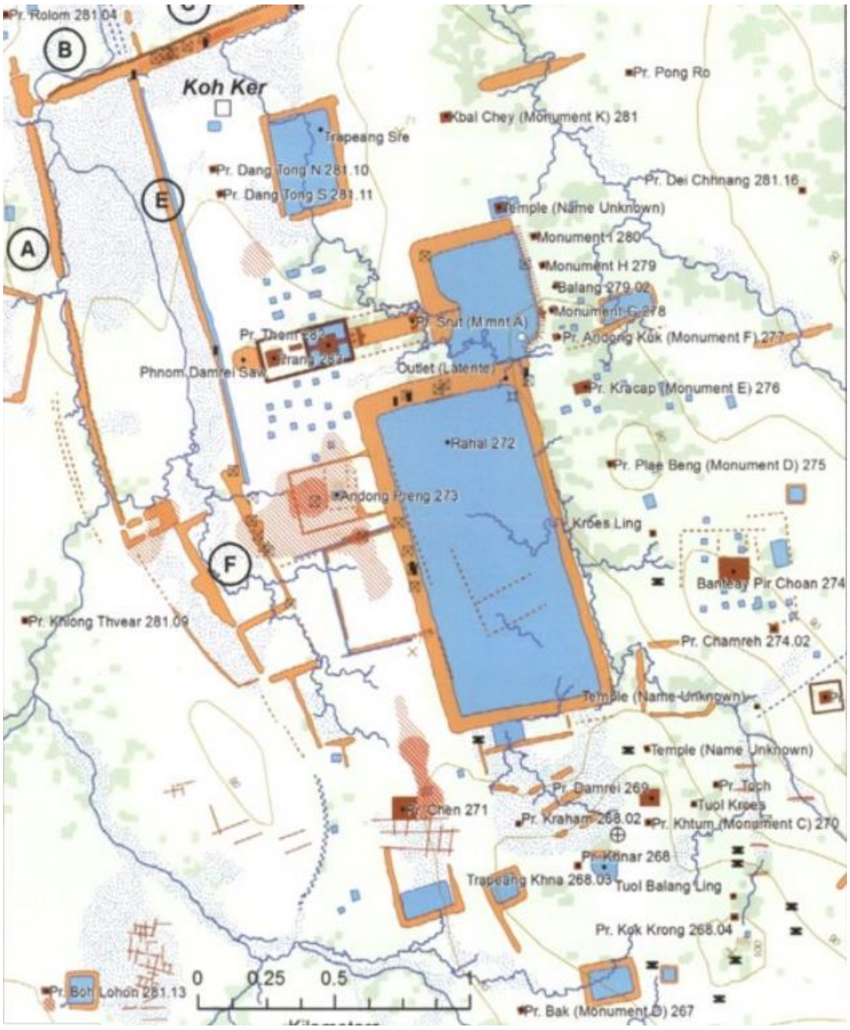

Fig. 11: The Kor Ker urban restitution after recent archaeological survey, after Evans D. *Bulletin de l'Ecole française d'Extrême-Orient*, 2010, p. 141.

Kor Ker is presently (2020) on the tentative list of Cambodia for a possible World Heritage application, under the full name of: 'Koh Ker: Archaeological site of Ancient Lingapura or Chok Gargyar'; it intends to underline both the innovative urbanism and the global hydraulic system as bearing resemblance to both the classical Khmer model for the plains and adaptation to more mountainous contexts.

Preah Khan Kompong Svay[15] is a temple complex erected during the eleventh and early twelfth century, with some important completion works undertaken by Jayavarman VII at the turn of the twelfth and thirteenth centuries, in particular a 3-km-long *baray*. Located 80 km east of Angkor, the temple complex presents a series of four successive enclosures and a perfect final square water ring of 6-km sides with an exceptional irrigation system laid out in difficult terrain serving as a perfect example of colonisation by implementation of the 'hydraulic city' concept. Preah Khan is presently on the Cambodian Tentative List.

Fig. 12: Aerial view of Preah Khan Kompong Svay; its temple ensemble, city and hydraulic system of *baray* and square moat ring. © *Google maps, 2020.*

Beng Mealea is a large temple built during the twelfth and early thirteenth century located around 70 km northwest of Angkor on the flank of the Kulen Mountains. This is as an important stage along the royal road, built on the model of dike ways with masonry bridges with the temple extending across 14 hectares and surrounded by a large moat as reservoir. Beng Mealea is presently (2020) on the Cambodian tentative list for a possible World Heritage application.

Banteay Chhmar offers another example of a settlement by Jayavarman VII based on the model of a temple of square plan in combination with a large *baray* including a central *mebon* temple. It is located around 110 kilometres north-west of Angkor, close to the frontier with Thailand today. It is on the Cambodian Tentative List.

Phnom Kulen is a complex archaeological site in the Kulen Mountains including a city, temples, and a hydraulic system. Located around 30 kilometres north-east of Angkor, this precinct shows a series of evidence since the era of prehistorical cave art to the origins of Khmer civilisation and all through its history. There is abundant and diversified evidence to be found at Phnom Kulen inside what appears today as a forested landscape designated as a natural park. A recent LIDAR survey (aerial digital scan of the region) identified a large integrated hydraulic and agricultural ensemble; connected to an urban grid already known by classical archaeology. Phnom Kulen exemplifies a rural Khmer settlement with its hydraulic structure of around 40 square kilometres. However, the vision seems not to have been entirely achieved, which is especially evident through an incomplete large *baray*. Phom Kulen is on the Cambodian Tentative List.

[15] Different from the Preah Khan Buddhist religious ensemble of Angkor.

7. Threats, protection, and management

7.1. Mains threats

Natural factors have served as the foremost and most permanent threat to the Angkor civilisation and its heritage. The cities, temple complexes and hydraulic systems of Angkor were definitively abandoned in 1431, after the decline of the empire, a period of war during the fourteenth century and a final invasion ending the Khmer dynasty. History played out similarly for other Khmer sites with sometime a residual use of the remaining hydraulic system that continues to be used by local farmers and small communities to the present day. Frequently, natural vegetation invaded the former human settlements, progressively disintegrating built structures and taking over the hydraulic reservoirs and canals. Images of trees growing over Khmer temples are popular. This need to be addressed through careful attention and specific restoration works. An ever-present threat of nature taking over demands regular maintenance with special attention and competencies for heritage conservation.

Fig. 13: The amazing action of nature regaining its right at Angkor Park, 2013. © *Michel Cotte.*

Human abandonment or partial reuse of the unprotected sites constitute another possible threat. Conversely, allowing functional reuse by a local community may safeguard some important hydraulic attributes, but the challenge of preserving the integrity and authenticity of heritage remains. A large part of the high-quality Khmer constructions remained preserved for centuries. Wars and civil disturbances were responsible for notable destructions through the centuries, as was commonly prevalent elsewhere. The recent civil war of the 1970s and the Khmer Rouge era damaged the heritage, mainly due to abandonmen, but at times due to irresponsible local reuse and alterations.

For some heritage places, threat of flooding continued. This could be related either to the deterioration of the original, ancient Khmer irrigation and flood control system or at times due to its total abandonment and to the present system of water management. A case-by-case evaluation of such situations could be useful.

Today, heritage tourism constitutes a major economic issue in Cambodia, particularly for the site of Angkor and Seam Reap districts. There were 5 million visitors to Angkor Park, the delimited zone of the World Heritage site, in 2017 with a pre-pandemic prediction of a continued increase in numbers. This makes it one of the most visited World Heritage sites alongside Venice or Machu Pichu, with notable pressures for economic infrastructure and the risk of deteriorating site quality and thereby its exceptional value.

7.2. Protection, conservation and management

The site of Angkor benefited from a long initial effort, begun in the early twentieth century, for identification, conservation and restoration works by the 'Ecole Française d'Extrême-Orient'. The 1990s, with an inscription on the World Heritage List (1992), opened an era of new protection and valorisation with renewed international interest and enlargement of conservation partnerships. Diverse laws and decrees for protection were promulgated, both for cultural and natural heritage. A specific body for heritage management of the Angkor region was created (APSARA, 1995), under the umbrella of Cambodian national authorities and with technical and financial support of diverse international specialised bodies. A specific international committee (ICC-Angkor) ensured coordination for research and planning of the conservation projects. Management and valorisation of the site was passed to the Angkor Park Authority (2004). A new department of land use and construction management within the site was established collectively by the existing authorities (2008).

The management of Angkor presents some important specificities as an archaeological site. This is one of the largest in the world and probably the most visited of all. Simultaneously, the site supports a significant number of inhabitants, needing to preserve their way of life and their economic resources, focused on rural and craft-related activities. The area incorporates significant natural heritage to be preserved. APSARA has responded to some of these challenges through two notable contributions: 1) The Management Plan for an experimental participation of the local communities with specific support for their own community-level projects; 2) The tourism analytic programme to precisely follow the impact of tourism on monuments and site.

Sambor Prei Kuk was recently listed as a World Heritage in 2017, with a tourist frequency lower than at Angkor. A site authority oversees management and regulation for human development within the temple zone and surroundings (buffer zone). This objective is served; however, the conservation of monuments remains wanting and needs concerted efforts. A similar situation exists for jungle progression.

Conclusion

The hydraulic management heritage of the Khmer period in Cambodia is as amazing as it is unique. This is exceptional for a number of reasons: (1) The geographic extension of the Khmer hydraulic system, a large scale achievement and regional diffusion; (2) An accurate understanding of the hydraulic regime and climate related to hydrography and possible agricultural uses of soil; (3) The engineering and the practical know-how required for this large water control, water storage and water distribution system, especially the construction of large surface reservoirs (*baray*) with adapted techniques; (4) the large-scale territorial planning for a rational use of water all through the year, especially for intensively irrigated crops; (5) The exceptional network of dike ways both for water control, flood protection, irrigation and the transportation system; this includes remarkable bridges with numerous corbel arches also serving as dams for water regulation; (6) The exceptional urban and social integration of the hydraulic system with the urban planning of cities and implementation of temples; this point underlines the deep corelation of rational water management and of social organisation; water symbols and associated religious beliefs express an array of meanings and values; such a phenomenon is unique at a this height of accomplishment and beauty.

The water management heritage value merits being studied and well understood, both for inhabitants within their current relationships with water management and irrigated agriculture, and for presentation to visitors as a key point of the valuable contribution of the Khmer heritage. Research in the domain has existed for a long time, but needs to be pursued and updated, and linked to the emergence of new investigation technologies such as pollen analysis or LIDAR surveys. These already exist in Cambodia and must be supported and further developed. International involvement in the preservation of Angkor heritage should be an important basis for new studies, while ensuring that the scope is enlarged through new programmes beyond the lone official 'Angkor Park' and its current focus on the restoration of temples and monuments.

A final question that needs some attention is related to whether Khmer hydraulic achievement serves as an example of sustainable development for today. As early as the 1970s, some expert historians and archaeologists, such as Bernard-Philippe Groslier, paid specific attention to the ancient water management by successive eras of the Khmer civilisation. This was supported by documented field enquiries about the rise, apogee and decline of the Khmer 'hydraulic city' (Groslier 1974, 1979). He drew particular attention to the link between the decline of the Khmer empire and the weakness of their hydraulic system. The hydraulic regime of the monsoons in conjunction with relatively poor soil quality led, over time, to a series of cumulative problems: (1) Regular clay sand deposits on the bottom of reservoirs, canals and moats that tended to progressively fill them; this phenomenon is relatively intense in the Cambodia climatic context; (2) Clay sand deposits also tended to hinder or completely block the gravity system of irrigation, as it generally operated at very low gradient; (3) the maintenance required to clean the whole system posing a cumbersome permanent constraint needing a well-organised social system without societal or war troubles; (4) Sandy limon on irrigated agricultural soils reduced fertility, and over time increased waterproofing of rice fields, with a negative effect on crop quantity and quality; (5) Broadly speaking, the quality of soil slowly degraded over time and was accentuated by the goal of intense productivity, with a demand of up to three crops a year. These constraints could not be professionally managed leading to increased fragility of the system when it became vulnerable to dramatic, unexpected natural or human events.

Alternatively, the history of resilience of irrigated agriculture in the region continues till today with examples of efficient reuse of past structures underlining those diverse facets that the 'hydraulic city' had in fact displayed a very sustainable role through time. A clear and objective reassessment of water management heritage in Cambodia is a classic example both for a better understanding of water use in the past and of its long-lasting ecological consequences. This should offer precious data to respond to the crucial question of sustainable development in the region citing the most remarkable example of all.

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12. Laos

Case study: Site and landscape of Vat Phou, Lao People's Democratic Republic

By Michel J. Cotte, University of Nantes (France) and ICOMOS Adviser

1. Description and attributes

The historic site of Vat Phou is located in the middle zone of the Mekong River forming the southern part of present-day Laos. Vat Phou (or Vat Phu) literally means 'the temple of mountain'. The site offers a cultural landscape that stretches from the foothill of Phou Kao Mountain in the west, to the Champasak plain along the Mekong River in the east. It contains the Vat Phou temple ensemble, a significant example of both early and classic Khmer culture of the seventh to twelfth centuries AD, with notable local specificities. These are expressed by a series of remarkable temples, shrines, ritual terraces, alleys, water reservoirs (*baray*s) and associated channels. The ensemble as visible today does not exactly conform to the west–east orientation as adopted in traditional Khmer settlements, but closely adapts to the topography of a gradual slope to the alluvial plain of the Mekong River.

The axial line stretches over 1,400 m, from the west point '*Linga*' (phallic-like monument) on the mountain, through a freshwater spring with a sanctuary, successive terraces with shrines, to the two main *barays* in the east. The temple complex was oriented and planned along the main axis including the two water reservoirs, with intentional symmetric effects. Nevertheless, successive historical periods of construction added some particularities. The ensemble expresses both social organisation and water management functions with important symbolic associations. Most of these attributes were planned to reflect the sacred Hinduist value of the builders of the Vat Phou ensemble and the worship practices of the associated city of Shrestrapura and broadly of the Champasak region.

Fig. 1: Vat Phou ensemble, Champasak Plain and Mekong River © *Google maps 2020.*

The temple complex lies at the foothill of Phou Kao and offers natural views to the mountains in the west and north, and a perspective on the two grand '*baray*s' towards the east; beyond, it encompasses the Champasak Plain which remains mainly devoted to rice cultivation using water from the mountain, as was certainly the case during past times with additional regulation offered by the *baray*s.

The site includes the archaeological remains of Shrestrapura City, on the bank of the Mekong River. This is one of the oldest known urban settlements in south-east Asia which also showcases later reconstruction as a Khmer planned city. Furthermore, the site presents archaeological evidence of ancient territorial organisation for fields and ways from the Khmer period, in close relationship to the Vat Phou ensemble.

The original design has a wide visual intent, related to symbolic meanings conveying to people an understanding of social harmony and religious value. This depicts a cultural landscape as is presently used by the World Heritage Convention.

Fig. 2: Aerial view shows the excellent conservation of the structural design of Vat Phou complex and its implementation at the foothill of Phou Kao Mountain. © *Google maps 2020.*

2. History and heritage of the water management of Vat Phou

The history of the Vat Phu ensemble as a living and evolving site covers more than five centuries. The pivotal point was probably the initial construction of the foothill sanctuary, linked to the water spring at the base of the steep mountain slope. This forms the origin of the axis, both for territorial organisation and water management. The oldest *baray* was certainly at the southern part of the site which today is almost entirely desegregated with little evidence of its existence. Nevertheless, its location and dimension may be estimated to be about 400 metres long near the main final axis. This was supplied by the water spring within the sanctuary. For some unknown reason, but perhaps due to the limited amount of the water spring and/or possibly, the need for rice field extension, a second *baray* was erected towards the north of the site; this *baray* was 500 metres in length and 170 metres in width which catered for additional water storage of around 200,000 cubic metres. This has been relatively well conserved to date and corresponds to perfect west–east alignment with the sanctuary illustrating the pure Khmer tradition. A relatively important stream to the north supplied this second *baray*. Today we can see the remains of its diversion canal settled outside the northern dike of the *baray*, with a substantial width of 25 metres. Other external traces of water management and irrigation canals are also notable here.

These initial two *baray*s were constructed early in the Khmer period, before the tenth century. They showcase two successive difficulties faced by communities. The first *baray* was abandoned probably due to the lack of water supply. The second *baray* which strictly followed the implementation of the Khmer concept of alignment, finally suffered from unsustainable topography, with insufficient gradient to avoid and wash sandy limon from the reservoir. Relatively rapid sedimentation due to insufficient natural drainage of sandy water hampered its use in the long run, and it probably required heavy maintenance works.

The third *baray* corresponds to the Khmer apogee from the end of the tenth to the eleventh century. This clearly benefited from the experience of the two initial Vat Phou *baray*s and from other places such as Angkor, with significant extension of the stone temple construction and hydraulic management. The design followed the main direction of the slope, at an angle of 15° south of the west–east line. The site was entirely reconceived along this alignment, following more the topographic reality rather than a spiritual concept. With dimensions of 550 metres in length and 175 metres in width, the third *baray* was completed through a vast campaign of constructions and renovations during the reign of Jayavarman VI (1080–1107). During this time, the sanctuary was reshaped as was the system of terraces. New palaces and temples were added along the main axis of the sacred ensemble contributing to the

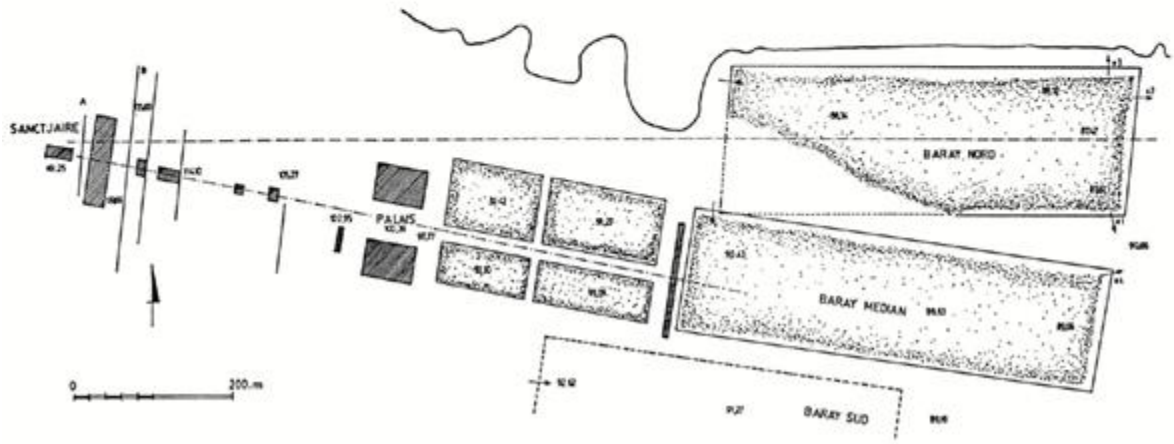

Fig. 3: Restitution of the different Vat Phou *barays* (artificial surface water reservoirs) implementation related to the two successive structural axes of the site, after Jacques Dumarçay, 'Notes d'architecture khmère', in: Bulletin de l'Ecole française d'Extrême-Orient, tome 79 N°1, 1992, p. 148.

heritage we see today. Others works were launched at the turn of the twelfth and thirteenth centuries but not completed, perhaps due to a partial collapse of the northern cliff of the site and the relative decline of the Khmer civilisation. Archaeological investigations also prove the existence of additional surface water reservoirs along the main axis, between palaces and the monument access to the main *baray*.

3. Protection, conservation and threats

The Vat Phou ensemble is both an archaeological site and a cultural landscape including remains of large hydraulic works and setting of the Champassak Plain. It was recognised as being of exceptional and universal value and listed as World Heritage in 2001, under criteria (iii), (iv) and (vi). The significance of water management was very briefly noted in the short description and not included in the criteria texts. The scope of the initial nomination focused on religious meaning and architectural value presented mainly as a 'Temple Complex'. Consequently, we recommend re-evaluation of the 'Outstanding Universal Value', paying more attention to the water management system, its attributes and significance.

The State of Laos, through provincial and local public authorities, is the main landowner of the nominated property and ensures legal protection of the site as well as implementation of conservation measures. A local management office oversees the site, ruled by the Province of Champassak, and a conservation plan has been prepared with the support of UNESCO and international cooperation.

The main factors affecting the site are natural environmental pressures, mainly: flooding, run-off and erosion, natural phenomenon intensified further by climate change. This has resulted in various types of damage to the buildings and terraces. Deforestation during the second half of the twentieth century and early twenty-first century led to further degradation. Second, demographic, and economic development has exerted immense pressure on the immediate surroundings, even though most of the population resides some distance away from the archaeological site. A new road visually affects the site and its landscape character. Planned projects may further impact the site due to the introduction of a modern water supply system and construction of diverse buildings and housing projects in proximity to the site. Control and regulation of these different issues in close relationship with the Vat Phou heritage constitute a key challenge for effective and sustainable conservation of the site in dialogue with local communities and public agencies. It is critical to share with them the value of the place and to implement appropriate impact assessment evaluations to precede final decisions.

Fig. 4: The main Vat Phou axial view from the water spring sanctuary to the ritual valley with lateral temples and palaces up to the final *baray* (large surface water reservoir) and its monumental gate. © *UNESCO, Richard Engelhardt.*

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13. Thailand

Case study 1: The Historic City of Ayutthaya, its water management heritage

By Hatthaya Siriphatthanakun, Specialist in Cultural Heritage Conservation at Southeast Asian Ministers of Education Organisation Regional Center for Archaeology and Fine Arts and ICOMOS Board member

The Historic City of Ayutthaya was inscribed on the World Heritage List in 1991, under criterion (iii).

Introduction: Description of the property

In 1350 AD Ayutthaya was established as the administrative centre of the Siam kingdom which developed into present-day Thailand. Ayutthaya is located on the Chao Phraya River Delta, between Chao Phraya River, Pa Sak River and Lopburi River, on an area identified as the lower flood plain, around 100 kilometres from the Gulf of Thailand. It is unclear when exactly the city was shaped by canalisation which transformed it into an island among the three rivers. As a result, Ayutthaya has been called the City Island or Koh Muang. In the natural context, it is claimed that the city was settled strategically amidst the three rivers which connected it to a maritime trade route, while protecting the heart of this Kingdom from sea battles as well as seasonal tidal flooding and inundation. The part of the canal system which continues to exist within the city demonstrates technologically advanced water management in the world at that time.

Fig. 1: Location of Ayutthaya.

Culturally, Ayutthaya was influenced initially by various ancient civilisations emerging in the Indo-China peninsula especially Khmer, Mon, China, and India. For 417 years Ayutthaya flourished into one of the largest urban centres for commerce and diplomacy in the world. The city was destroyed by the battle between Siam and Burma in 1767 AD. Thereafter the Kingdom moved its centre to the present location of Bangkok. At present, the Historic City of Ayutthaya is an archaeological complex situated within the contemporary town. The remains of a highly refined decorated royal palace and stupas as well as an enormous number of temples exhibit the past splendour of this historic city. Furthermore, this place showcases important heritage of water management from this period.

1. Canalisation: Water heritage of Ayutthaya

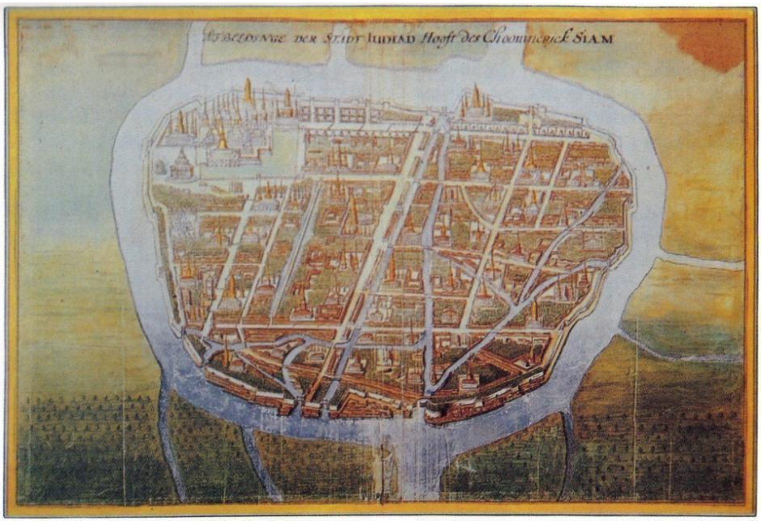

Fig. 2: Vingboons, Johannes (1663). Vingboons' maps named Iudea. *Source: Chumsai Na Ayutthaya, S (1986). Water: the Origin of Thai Culture. 184. Bangkok: Thaiwattanapanit Ltd.*

As previously mentioned, Ayutthaya had one of the most advanced technologies in water management in its golden era which is evident from the canals constructed during 1350-1767 AD. From historical documentation such as chronicles, old maps ('Iudea' by Vingboon, 1663) and pictures drawn by foreign visitors to the Kingdom, as well as the remaining water management system, it is evident that many canals were dug to control water for various purposes. However, studies and research on the water management system of Ayutthaya is quite limited. According to Tanabe (1971), the canals built in the Ayutthaya period can be categorised into three types owing to their patterns and functions as follows:

1.1. City moats and internal canals

The date has been argued for years and it remains unclear when the moat that shaped the island city of Ayutthaya was dug. According to its location, Ayutthaya sat strategically amidst the three rivers. Subsequently, a canal, namely *Khu Na*, was dug to connect the rivers and encircle the city. The Royal Chronicle maintains that further to building an encircled city, the moat aimed to mainly protect from enemies. The internal network comprised of principal canals flowing straight from north to south while the narrower ones were laid out in the east-west direction. It is claimed that the principal canals were used to control water during the flood season by diverting water through the city as quickly as was possible. In contrast, the smaller canals could be used for transportation within the city, as was mentioned in a historical document that boats were the main means of transport in Ayutthaya. Additionally, canals in the city may have been used for domestication, especially in the dry season.

Fig. 3: The city moat at the north of the city today.

1.2. Short-cut canals

Along the Chao Phraya River, shown as *Mae Nam* in several old maps, extending from Ayutthaya to the Gulf of Siam or Thailand, several short-cut canals were constructed to reduce distances and facilitate transportation. These canals aimed to support and strengthen trade and commerce between Ayutthaya and foreign countries.

1.3. Transverse canals

Two transverse canals, Samrong canal and Mahachai canal, are mentioned in various historical documents. According to the Royal Chronicle, around 1498 AD, Samrong canal was dug as a linkage between Chao Phraya River and Bangpakong River in the east while Mahachai, a man-made canal was dug in 1704 AD to connect Chao Phraya River and Tha Chin River in the west. With the help of the canal network including the short-cut and transverse canals, Ayutthaya Kingdom ruled over and controlled both inland and sea trade, and commerce of the Indo-China peninsula. Samrong and Mahachai canals still exist and are important water transportation networks when compared with roads.

2. Other remaining water-related heritage of Ayutthaya

Besides the canal network, there are other examples of water-related heritage of Ayutthaya that can still be seen or traced as follows:

2.1. Water gates

From several old maps drawn by foreigners who visited Ayutthaya in the seventeenth and eighteenth centuries, it can be seen that water gates were placed at junctions where the main canals connected to the city moat in order to control the water level within the city. On one hand it is believed that the water gates were likely spillways to allow overflow when water reached a certain level. Another assumption is that the water gates were temporary timber structures that could be built with a short period before the flood period. So far, the ruins of water gates at the royal palace and a temple, have been identified. Unfortunately, the whole picture of these two water gates and how they functioned remains unclear due to limited existing studies or research.

2.2. Bridges

Similar to the water gates, there are references to several bridges in the old maps. This is not surprising as the main principal urban structure of the city was comprised of canals therefore bridges were the common elements for the pedestrian system. It has been claimed that more than 30 bridges built of brick, timber or even laterite, were constructed. Only the remains of some of the brick bridges structures have so far been found.

Fig. 4: One of the remaining bridges which is now under threat from new constructions. Traces of the canal can still be seen. *(Source: https://www.matichon.co.th/education/religious-cultural/news_1600373)*

2.3. Water irrigation: terracotta water pipes, water tank

Within the archaeological complex of the remains of the royal palace, a standing structure, made from brick with lime plastering believed to be a water tank serving domestic use in the palace has been found. From archaeological excavation, bronze and terracotta water pipes were discovered. It is claimed that a water wheel used to pump water from the river to the water tank that was located within the palace. However, there is no evidence of the water wheel except for a brick-structured stand on which a water wheel is usually placed.

Fig. 5: Remains of water tank located within the ruin of the Royal Palace at the Historic City of Ayutthaya. © *Ken May.*

Conclusion

At present most of the physical remains from Ayutthaya's glorious period can be seen at the Ayutthaya Historical Park, a statutory protected area covering around half of the City Island also the site of the World Heritage Property. A few remains of water-related heritage such as bridges and possibly a water gate can be seen around the contemporary part of the City Island. However, the whole City Island including the Historical Park and the internal canal system is legally protected as a National Monument. With limited study and research, but comparing with canals seen in Kaempfer's map of 1727, half the number of canals can be identified above ground though the system hardly functions today. The canals are mainly used for drainage purposes. It is worth noting that the width and depth of the city moat has transformed from its original state due to the changing of upstream rivers affected by the construction of several major dams and the present water management within City Island.

After Ayutthaya was flooded in 2011, there were a few attempts to pursue research on the canal system of Ayutthaya to propose flood mitigation measures. Somehow the research was based on recent conditions rather than understanding the canal system from its historic emergence to the present day. Therefore, the construction of major infrastructure to protect Ayutthaya City Island has been proposed. For example, it was proposed to level the road around the City Island which was built on the remains of the city wall. Another proposal was to construct a water barrier structure around the City Island. The proposals, fortunately, have not been implemented so far. In addition, recently, a new hi-speed train station has been proposed outside the City Island which is the earliest part of Ayutthaya and can be seen as the footprint of the water-related culture of the historic settlement. It is regrettable that this area is not protected legally yet, even though it has been universally recognised among scholars interested in Ayutthaya Studies. Some of the short-cut and transverse canals are registered as national monuments. Even then the physical appearance of these canals has also been altered over time and the recognition of this water-related heritage amongst people is intrinsically limited.

It is evident that water heritage of Ayutthaya represents advanced water management in that glorious era. However, heritage comprises of not only physical components of the water management system but its intangible aspects which are connected to the knowledge of people relating to their past such as the understanding of water character, water management, functions etc. This is crucial for resilient living which is sustainable. For this further and deeper study and research, as well as urgent protection of its footprint is much needed.

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Case study 2: Sukhothai Ancient City, heritage of landscape and water management (thirteenth-fifteenth centuries)

By Theerasak Thanusilp, Archaeologist, Archaeology & Fine Arts Departement, Ministry of Culture of Thailand

1. Sukhothai Ancient City Location

Fig. 1: The ancient city of Sukhothai. © *Theerasak Thanusilp.*

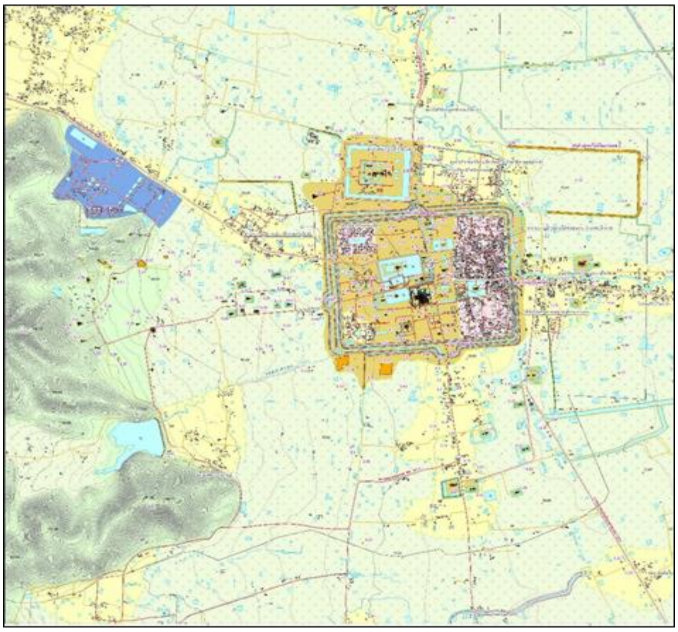

Fig. 2: Map of Sukhothai Ancient City. © *Sukhothai Historical Park, 2010.*

Sukhothai Ancient city (Fig. 1) is located on the northern edge of the Chao Phraya River basin. In addition, its western side is approximately 12 kilometres from The Yom River (Kitjaraksakun, 1985), in Sukhothai province, Thailand.

The 'Historic Town of Sukhothai and Associated Historic Towns' was inscribed on the World Heritage List under criteria (i) and (iii) in 1991. Its Outstanding Universal Value is expressed by: 'Sukhothai was the capital of the first Kingdom of Siam in the thirteenth and fourteenth centuries. It has a number of fine monuments, illustrating the beginnings of Thai architecture. The great civilisation which evolved in the Kingdom of Sukhothai absorbed numerous influences and ancient local traditions; the rapid assimilation of all these elements forged what is known as the 'Sukhothai style'.'

The location of the ancient city features the sloped plain area on the outskirts of the forest. Streams, especially Mae Lamphan main stream, flow down from the mountain range from the northwest of Sukhothai city while there are large ponds to the east.

2. Sukhothai Geography

Sukhothai Ancient City was found to be located on the foothills. It is sloped from the west to the east. In line with satellite imagery and geological data, the establishment of Sukhothai Ancient City is primarily based on physical environmental factors. The LANDSAT ETM image shows the city in a location which withstands flooding from the dark zone. The main stream is coloured light blue (top middle) and the Yom River is the dark blue line on the right of the image. (Fig. 3)

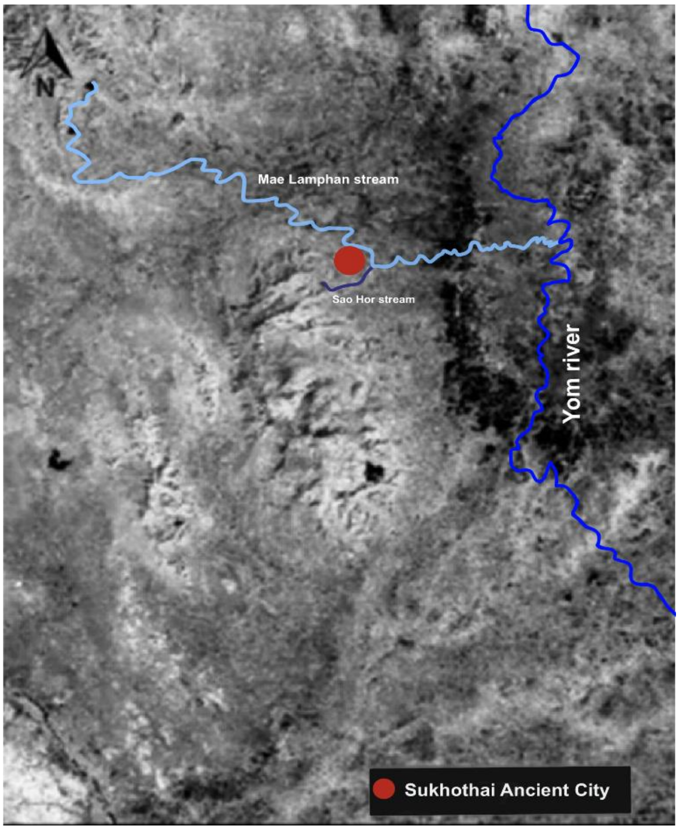

Fig. 3: The location of Sukhothai Ancient City, LANDSAT ETM image. © *GISTDA, 2013.*

3. Sukhothai inscriptions and landscape interpretation

The Sukhothai inscriptions which are associated in the field of Landscape perspective and dynamic of cultural management, are divided into three significant periods (Table 1): 1. The reign of King Ramkhamhaeng, 2. King Li-Thai's reign and Late King Li-Thai's reign. The inscriptions give a good description of the landscapes.

Reign	Inscriptions	Dating	Significant Details
King Ramkhamhaeng	Sukhothai Inscription no. 1 (King Ramkhamhaeng's inscription)	**1284 AD**	Describes the landscape of Sukhothai. For instance, the market called *Pasan market* at the north side of the city. The residential area is to the east. The Saridphong (Sukhothai ancient irrigation) is on the west.
King Li-Thai	Sukhothai inscription no. 2 (Wat Si Chum)	**1392 AD**	Describes the boundaries of Sukhothai state.
	Sukhothai inscription no. 3, 4 (Wat Pa Mamuang inscription)	**1361 AD**	This inscription describes landscape management at Aranyavasi- forestry area on the west side of the city in various languages such as Pali, Khmer, Sukhothai and also Sanskrit. This is the main area which King Li-Thai was established to be a ritual area for Buddhist and Hindu which are the main beliefs of Sukhothai people to control and manage the landscape by religion.

Late King Li-Thai	Sukhothai Incription no. 59 (Wat Burapharam inscrition)	**1417 AD**	This was made by the Queen of King Li-Thai. It mentions that the Queen established four temples in the east of Sukhothai city in honour of King Li-Thai who had died.
	Sukhothai Inscription no. 25 (Wat Sorasak inscription)	**1417 AD**	This is the last Sukhothai inscription. It was found in Wat Sorasak temple. It describes the history of the temple in Late Sukhothai and the residential area of leadership of Sukhothai at that time which is located on the west side of Wat Sorasak temple within the city moat.

Fig. 4: Table of Sukhothai inscriptions and landscape interpretation

4. Irrigation system of Sukhothai Ancient City

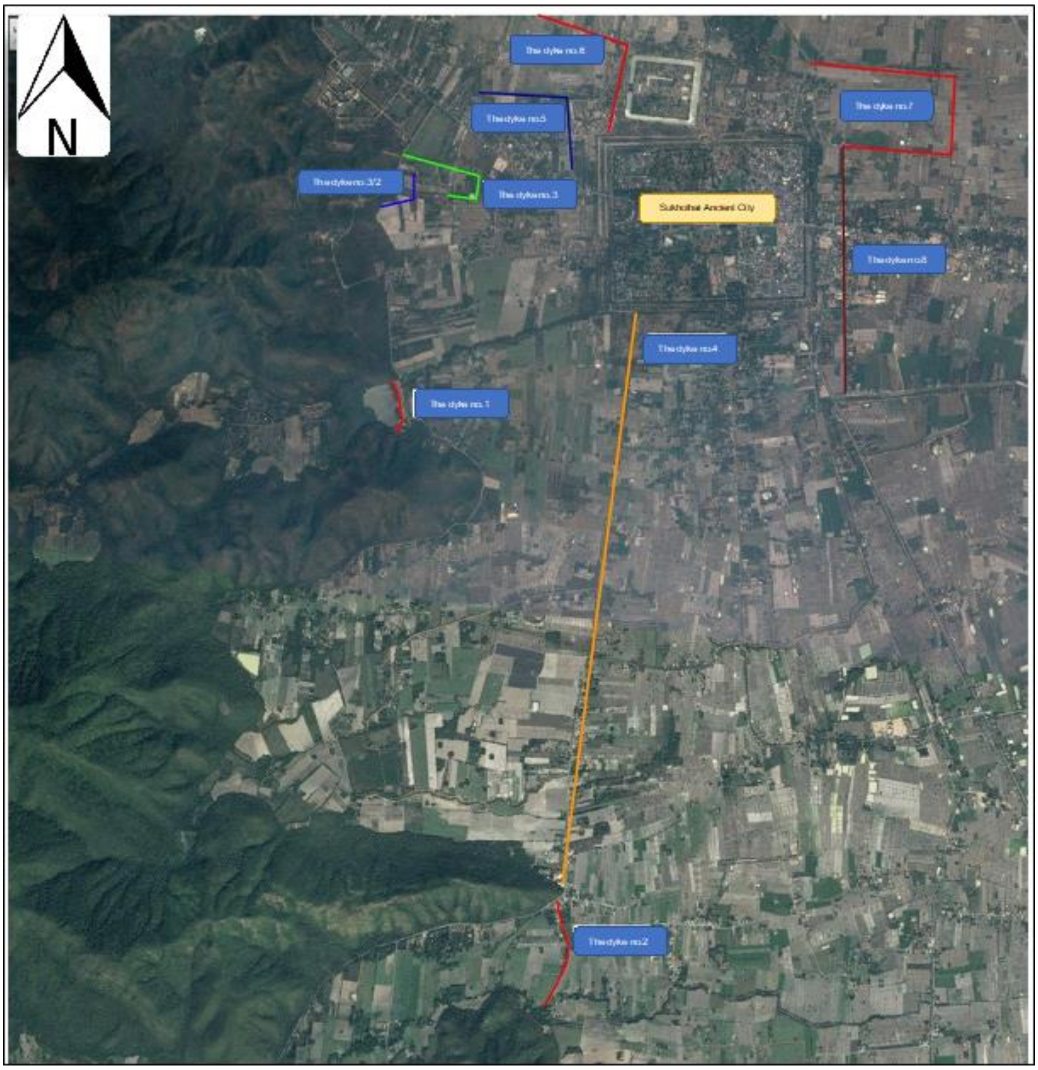

Fig. 5: The distribution of Sukhothai Irrigation System (ancient soil dikes). © *Sukhothai Historical Park, 2017.*

In the first inscription of Sukhothai (King Ramkhamhaeng's inscription), the significant evidence mentioned 'Sa Reed Phong' (Fine Arts Department,1984) which comes from the Sanskrit word meaning dam or earthen dike. It is located approximately three kilometres southwest of the ancient city. This earthen dike linked Khao Kiew Eye Ma and Kha Phra Bat Yai. The water from the dam or water tank can be drained through Klong Sao Hor canal to the southwest corner of Sukhothai city moat (Sihamat, 2014).

Within Sukhothai city, there were approximately 175 man-made water resources. They were built from various materials such as brick or laterite. For example, there are rectangular or round shaped brick wells (Fig. 4) and laterite wells (Fig. 5) which were distributed in Sukhothai Ancient City within the city moat. According to archaeological research, there is also a wide area of Sukhothai. Another issue to consider are the restrictions of the terrain, because the city is growing rapidly. The large population also leads to greater demand for water and natural resources. Sukhothai is characterised by a terrain that is vulnerable to dehydration due to its low mountain land. From the water management point of view, it is interesting to note that the ponds rarely have brick wells. The area near the narrow valley uses high soil ditch construction to slow down and hold water for a period. This is evidenced by earthen dikes no.1-no. 2, no.3, and dikes no. 3/1–no. 3/2. However, away from the wide foothills, it uses the construction of water levers to determine the flow direction of the water and reduce the strength of the current, so that it would not clash with the location of the community. It flows down the west moat and flows through the north or south moat before flowing down the Mae Lamphan stream on the east side of the moat. The area outside the eastern city is a lower area on the west and the north side, appearing to make two water barriers, namely, to make dike no.7 and the following dike no. 8. This could indicate that there was a densely populated community on the east outside the farming landscape.

Today, the Sukhothai ancient irrigation as the representative of Sukhothai innovation can be interpreted as Sukhothai landscape management of the Sukhothai ancient people which has been preserved and developed as a part of World Heritage. In addition, it still effectively nourishes the people of this valuable World Heritage Site.

Fig. 6: Square-shaped brick well within the Sukhothai city moat. © *Theerasak Thanusilp.*

Fig. 7: Round-shaped laterite well within the Sukhothai city moat. © *Theerasak Thanusilp.*

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14. Philippines

Case study: The Rice Terraces of the Philippines Cordilleras

By Pierre-François Toulze

The rice terraces of the Ifaguao ethnic minority are located in the remote areas of the Philippine Cordillera mountain range on the northern island of Luzon, Philippine archipelago. They are situated at altitudes between 700 and 1500 m above sea level and are spread over most of the 20,000 km^2 land area covered by the provinces of Kalinga-Apayao, Abra, the Mountain Province, Ifugao, and Benguet. In this region, water is abundant for irrigation and Ifaguo is one of the wettest rice-growing regions in the world[16].

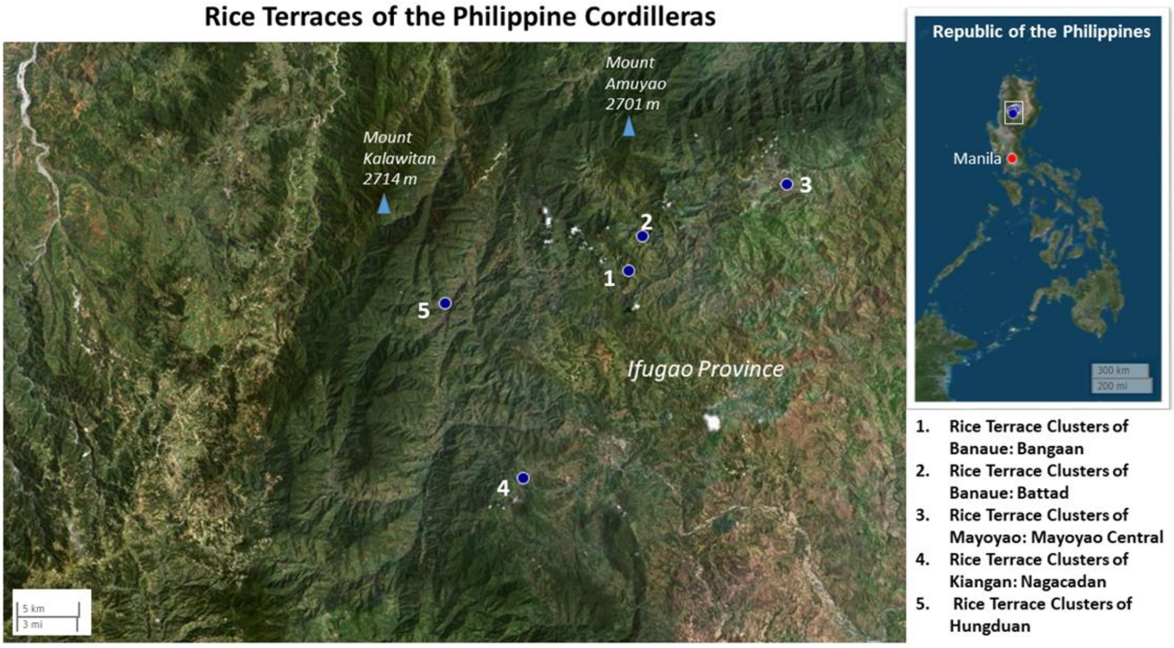

Fig. 1: Map of the rice terraces. © *P.-F. Toulze / Open Street Map.*

The historic terraces cover an extensive area, five of them were inscribed on the World Heritage List in 1995 with the criteria (iii), (iv) and (v): the Bangaan terrace cluster and its typical Ifugao traditional village; the Batad terrace cluster that is nestled in amphitheatre-like semi-circular terraces with a village at its base; the central Mayoyao terrace cluster which is characterised by terraces interspersed with traditional farmers' bale (houses) and alang (granaries); the Nagacadan terrace cluster, with two distinct ascending rows of terraces bisected by a river; the Hungduan terrace cluster that uniquely emerges into a spider web. Justification of criterion (iii) states that: 'the rice terraces are a spectacular testimony to a community's sustainable and primarily communal system of rice production, based on harvesting water from the forest-clad mountain tops and creating stone terraces and ponds, a system that has survived for two millennia'.

[16] This article is mainly issued from the nomination dossier.

Fig. 2: Banaue Rice Terrace.

Built around 2,000 years ago, these terraces are located at a higher altitude and on steeper slopes than many other terraced cultures (70° maximum as compared with 40° maximum in Bali, for example). The technical mastery of Ifugao was notably materialised by the development of intricate irrigation systems, harvesting water from the forests of the mountain tops.

The rice terraces of the cordilleras are also the only form of stone construction from the pre-colonial period in the Philippines. Taro was the first crop, later replaced by rice, which is the predominant crop today. The rice terraces are an expression of the lfugao's mastery of the watershed ecology and terrace engineering and it is clear that a high level of knowledge of structural and hydraulic engineering had been necessary on the part of those who built the terraces.

To contain the water needed for rice cultivation within the paddies, even gently rolling terrain must be terraced with stone or mud walls. Moreover, high-altitude paddies must be kept wet and must rely upon a man-made water-collecting system. The construction of the terraces is carried out with great care and precision. A course of marker stones is first laid out on a concave slope, backed by heavy broken gravel fill set into cuts in the natural slope to prevent slippage. As each course of dry-stone walling is added, the level of fill is raised. To allow for proper drainage of a covered internal water source farther back from the embankment, an underground drainage conduit kept free of gravel and silt by means of bundled Miscanthus canes protected by flat slabs of rock was placed so the normal flow would be conducted directly to the outer wall.

When the level of fill reaches within a metre or so of the desired height, a layer of hard-packed earth is laid down on the gravel fill, as the base of the 20-30 cm of soft, thoroughly, worked clayey topsoil. The stone walling is on average about 2 m high, though some walls may rise to as high as 6 m. Groups of terraces rise from valleys up the slopes of peaks continually covered with mist. No terraces are found below the sunny mountain peaks. Their irregularly shaped walls follow the forms of the mountain sides to which they are anchored.

Above the terraces, rising to the mountain tops, is the ring of private woods, the muyong, which are intensively managed in conformity with traditional tribal practices. Forest vegetation is therefore meticulously supervised by each owner, who understands that his own forest forms one part of the total ecosystem that assures adequate water supply to keep the terraces constantly flooded for agricultural purposes and to prevent the layers of packed mud underneath from drying out and subsequently causing damage to the terrace walls.

Water is equitably shared, and no single terrace obstructs the flow of water on its way down to the next terrace below. There is a complex system, of dams, sluices, channels, and bamboo pipes, communally maintained, which drain into a stream at the bottom of the valley.

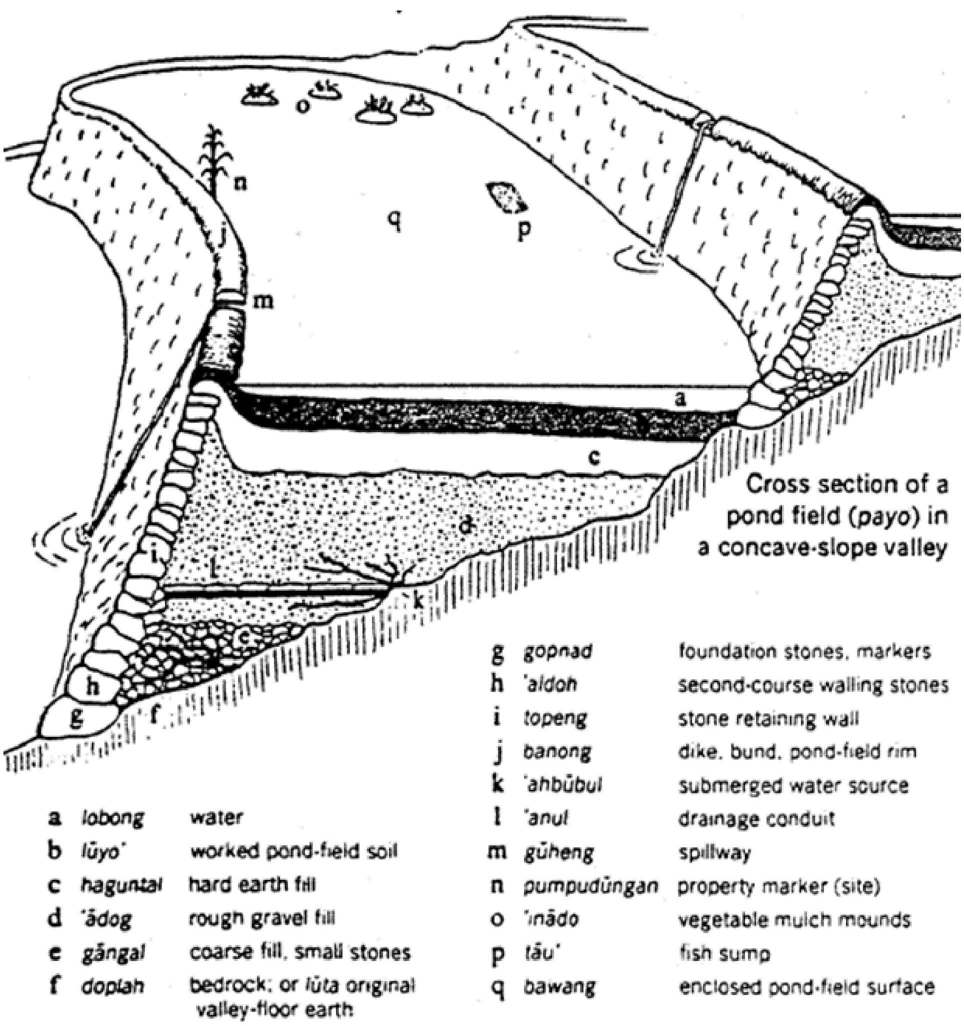

Fig. 3: Pond-field terrace composition. © *The Rice Terraces of the Philippine Cordilleras' nomination file.*

The irrigation system in the rice terraces, essentially drawn from springs, is composed of several elements:

The collecting canals are constructed to catch the water which runs off and drains from the mountain slopes above the terraces area and conducts the water to the corresponding irrigation canal. Collecting canals always run along contours. A collecting canal is constructed almost horizontally to minimise drop and to control erosion. The canal is either excavated in the rock or is bordered by a bund consisting of a row of flat stones placed in a groove. The size of the canal depends on the amount of water which it normally has to conduct. The average width varies from about 40 to 50 cm, the depth from 30 to 40 cm, while the length may vary from about one hundred to several thousand metres. An irrigation and/or drainage canal directs the water to the trenches or directly to the terraces and drains excess water. Thus, in terraced areas, provisions must be made for the water to come down in steps. The required alterations in the beds of the mountain stream are made by filling certain parts of the original stream beds with stones, or by deflecting the stream sideways by means of a number of short, almost horizontal canals, connected by cascades. The trenches direct the water from an irrigation canal to the highest point of a terraced area and run along contours. Trenches are used exclusively to direct irrigation water. They are normally found on the slopes just above the terraced areas. In a few cases a trench is found to cross a series of terraces. Trenches generally have smaller diameters than collecting canals.

Fig. 4: Hike through the rice terraces of Banaue, from the viewpoint back to town. © *Caitriana Nicholson.*

The water distributing constructions are used to divide a single stream into two branches. The water is distributed by digging a branch canal upstream of a waterfall or cascade or by cutting an almost level furrow in the course of a fall. A level watercourse is usually split by placing some big boulders in the bed of the stream at a distance upstream of the division into two branches. The tubes are used as a continuation of an irrigation or drainage canal underneath a terrace in order to gain terraced area. Inlets and outlets distribute the water from an irrigation canal or trench on the terraces, or drain the water from upper to lower terraces and this is usually accomplished by means of a simple overflow. When a canal runs between two terraces, water is let in by removing a stone from the boundary wall. When terraces do not border each other, the irrigation from upper to lower terraces can be accomplished by conducting the water through bamboo tubes or hollow tree trunks. Internal drainage is sometimes used in terraces which may be expected to receive much water after heavy rainfall. The drains, which are dendritically distributed in the soil of the terraces, consist of stone cases filled with faggots.

The irrigation method corresponds to the different topographic settings of the rice terraces. For rice terraces on V-shaped valleys of larger rivers, the irrigation and drainage canals intersect the terraces. The irrigation water is conducted through scalariform canals, running perpendicular to the contours or by trenches and subsequent upper to lower terrace irrigation. For rice terraces on tributary valleys, the irrigation system is very specific. The original water course in the centre of the valley is deflected into a scalariform canal running at a higher elevation along one side of the valley. Water flows in stages. For rice terraces on slip-off slopes, the irrigation water is usually conducted through a trench and then distributed by upper and lower terrace irrigation.

So, this system allows multiple harvests, first by allowing the area of land under cultivation to be extended to land that could not be flooded by rain or floods, and then by lavishing two harvests in a year thanks to water control. Nevertheless, the reduction in the workforce and other social and environmental factors, including changes in management of the watershed forests, makes this traditional system and thus the overall balance highly vulnerable and requires sustained management and conservation. The environment has also been severely damaged by deforestation. Because of that, the property was put in the List of World Heritage in Danger in 2001. At that time, about 25–30 per cent of the terraces were abandoned, which has led to damage to some of the walls. This arose because parts of the irrigation system had been neglected, which in turn is due to people leaving the area. However, the efforts made by the local authorities to restore the 42 communal irrigation systems of the rice terraces within the property for almost a decade have improved the overall state of conservation and in 2012 the World Heritage Committee decided to remove the Rice Terraces of the Philippine Cordilleras from the List of World Heritage in Danger.

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15. The cultural heritage of water in tropical and subtropical Eastern and South-Eastern Asia,

Conclusion

By Michel J. Cotte, Emeritus Professor of the University of Nantes, ICOMOS Advisor

In line with the first ICOMOS Thematic Study on water management as cultural heritage in the Middle East and Maghreb (ICOMOS, Paris 2015), we began to define a coherent regional ensemble, both hydrologically, climatically and culturally. As stated in our introduction, the topic of water heritage in Eastern and South-Eastern Asia was very suitable to such a requirement. Secondly, there was a need to establish a credible international network of authors with scientific and professional skills in the field, knowledge of the field as well as an ability to put these skills into a heritage perspective.

We have tried to have a balanced representation of the different regions and countries that make up this coherent, but vast and complex whole. Although guided by the common thread of the natural notion of sub-tropicality of the studied area and the cultural notion of rice civilisations, the geographical, climatic and historical diversities are important. The state of local studies of the vestiges of the past, regional sensitivities to the notion of heritage and its contemporary use, and the human and material resources available are also very variable. It was therefore not possible to present a perfectly homogeneous work, and even less so an exhaustive work, which is unthinkable and was never our goal. The aim was to provide insights, at two levels, one through overall analyses, at the scale of a region or a country, and the other by presenting some significant case studies of these heritages. These are therefore examples, and many others can and will soon be mentioned. We hope that the articles in this volume will provoke new initiatives, deepen the existing, and give new readings of properties where water management has been forgotten in a first and old definition of heritage value, only through the prism of traditional approaches to monuments, ensembles and sites. We also hope that they will help to provide methodological guidance for all those who have the opportunity to contribute to such projects.

The subject of water management as cultural heritage constitutes, frequently, a new open domain of research, at the intersection of various academic fields both related to exact sciences and social sciences such are hydrology, geography, archaeology, agronomy, civil engineering, heritage conservation, history, anthropology and etc. A multidisciplinary approach is therefore needed, both for synthetic regional approaches and for developing case studies. Consequently, ICOMOS's request to the authors was to encourage them to go beyond their classical competences, to extend it with new thinking, in particular for the understanding of the material heritage of water management, its conservation and its presentation to present generations. This effort to promote new perspectives on the understanding of heritage constitute an important facet of this Thematic Study programme. The group of authors gathered shows the effort made in this direction, but also the difficulty of the work that has been asked of them.

The results obtained show that the novelty of the subject of water management as a cultural heritage and as examples of sustainable development of ancient societies is a rather variable awareness from one country to another, from one subject to another. It is not uncommon for the heritage of water management to be neglected for a variety of cumulative reasons. Indeed, it is not always spectacular and its vernacular and repetitive character sometimes makes it seem of little importance. Very often it is still used in a mixed state, between traditional structure and technical modernisation, which tends to erase its heritage perception. In other cases, the knowledge of this heritage is essentially historical and cultural, that is to say, it is based on data of a social and memorial nature. But we have seen that in many regions and countries, the identification, study and protection of this heritage has emerged and made rapid progress. There is an awareness of a heritage that goes beyond the classical legacy of monuments, sites and urban centres. There is no contradiction between these two readings of the notion of heritage, because they can complement each other in a remarkable way, especially in this region of the World where magnificent examples of this conjunction exist in number. A heritage of a technical and functional nature therefore has its place today in the proposals that can be made to recognise and enhance them. The heritage of water management must now become a major element in the processes of analysis and study of material remains. It also ties in with the concerns of sustainable development, as it provides very direct examples of how our ancestors conceived, realised and used the vital resource of water. Finally, particularly in the subtropical humid regions studied, the surface of domesticated water is a major attribute of many cultural landscapes, to which it gives incomparable qualities of extent, perspective and aesthetics.

It should be remembered that in order to come fully within the scope of the 1972 World Heritage Convention, we must start with a well-preserved material heritage in a sufficient state of integrity and authenticity. But it is also possible to consider the conservation of traditions and representations in the field of water management as belonging to the domain of the 2003 Intangible Heritage Convention.

As in the other categories of heritage, we find a distinction between heritage of an archaeological nature and heritage that is still functional. The former has generally lost all functionality and is in the form of more or less complete material remains *in situ*. Their evaluation and conservation are similar to that of archaeological sites. The latter quite generally raises the question of its evolution and modern adaptations, which often affect their integrity and authenticity through the constructive materials used, structural changes and extensions, the addition of mechanical means, etc. However, it must be stressed that these modernisation efforts preserve the hydraulic functionality, often amplifying it, which can be seen as the preservation of a form of integrity (functional integrity) and authenticity (authenticity of use). It is therefore necessary to appreciate how and in which way these changes brought by the modern world and industrial technologies intervene. It is necessary to appreciate how the initial design and long-standing uses of the past have been preserved, how they are still legible in a given site and given environment, how the initial spirit endures or, on the contrary, has been too radically disrupted to be still recognisable. The challenge thus posed seems to us to be more delicate to solve than in many cases of classic heritage sites, and the stakes are even higher between testimonies of the past and projects for the future.

What is really very important in this regional ensemble of the Far East and South-east Asia is the multi-millennial management of water for rice cultivation, in all geographical conditions: plains, river deltas or mountains, and at all latitudes of the subtropical regions studied. This was known as a fundamental civilisational fact, of course, but it is the heritage approach to this data, in recent years, that constitutes something new. These cultural landscapes have already been recognised, others are being prepared, and management and enhancement programmes are underway. These heritages have incredibly ancient roots in many cases, showing the ingenuity of man and his collective efforts to control, conserve and use water for the sustainable life of human societies. At their peak, they reach incredibly vast dimensions, multiplying dikes, reservoir basins, artificial canals and terraces. They require knowledge of observation, rational deduction, anticipation and calculation, which form a practical science and a hydraulic technology, both of which are remarkable and transmitted by practice. The heritage of water management concerns transport and for this purpose the construction of artificial canals, in which this region of the world was a pioneer, thus completing and connecting the rivers and natural water bodies. In addition, man has learned to protect himself from the overflow of water, by means of dikes and sometimes extremely ingenious works. Archaeological research in this field never ceases to amaze, providing valuable evidence of the know-how developed for this purpose, to cope with the ravages of nature and its possible destructive effects. Finally, these water heritages can be read at finer territorial scales through case studies, that of local communities, towns or villages. They then provide the most convincing examples of the social organisation structured around water management and, beyond that, of the representations, traditions and beliefs associated with the different manifestations of water in human life.

To end this brief conclusion, we would like above all to thank the authors warmly for the time they devoted to the Thematic Study. It is really important for ICOMOS to be able to count on such availability. We also warmly thank all the people who were involved in this Thematic Study with the support of the ICOMOS office in Paris, especially Nupur Prothi and his successor Pierre-François Toulze for the management of authors and texts, Lucile Smirnof and her successor Angélique Ploteau of the ICOMOS documentation centre. Our thanks also go to Marie-Laure Lavenir, Director of ICOMOS, who ensured the material organisation and administrative coordination of the study, without which nothing could have happened. The same goes for the involvement of the national sections of ICOMOS especially in Korea, China and Japan, which played a decisive role in finding the authors best able to meet our expectations.

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A la suite de la première étude thématique de l'ICOMOS sur la gestion de l'eau en tant que patrimoine culturel au Moyen-Orient et au Maghreb (ICOMOS, Paris 2015), nous avons à nouveau cherché à définir un ensemble régional cohérent, tant du point de vue hydrologique et climatique que culturel. Comme indiqué dans notre introduction, le sujet du patrimoine culturel de l'eau en Extrême-Orient et dans l'Asie du Sud-Est convenait bien à une telle exigence. Ensuite, il fallait mettre en place un réseau international d'auteurs crédibles, ayant des aptitudes scientifiques et professionnelles dans le domaine, une connaissance du terrain ainsi qu'une capacité à mettre ces aptitudes dans une perspective patrimoniale.

Nous avons essayé d'avoir une représentation équilibrée entre les différentes régions et pays formant cet ensemble certes cohérent, mais vaste et complexe. Bien que guidés par le fil rouge de la notion naturelle de sub-tropicalité de l'ensemble étudié et de la notion culturelle de civilisations du riz, les diversités géographiques, climatiques et historiques sont importantes. L'état des études locales des vestiges du passé, les sensibilités régionales à la notion de patrimoine et à son usage contemporain, les moyens humains et matériels disponibles sont également très variables. Il n'a donc pas été possible de présenter un travail parfaitement homogène, et encore moins un travail exhaustif, ce qui est impensable et n'a jamais été notre but. Il s'agissait de fournir des aperçus, à deux niveaux, l'un par des analyses d'ensemble, à l'échelle d'une région ou d'un pays, l'autre en présentant quelques études de cas significatifs de ces patrimoines. Ce sont donc des exemples, et bien d'autres peuvent être évoqués et le seront bientôt. Nous espérons que les articles de ce volume provoqueront des initiatives nouvelles, des approfondissements de l'existant, des lectures nouvelles de biens où la gestion de l'eau a été oubliée dans une première et ancienne définition de la valeur patrimoniale, au seul prisme des approches traditionnelles des monuments, des ensembles et des sites. Nous espérons également qu'ils contribueront à donner des indications méthodologiques pour tous ceux qui ont la possibilité de contribuer à de tels projets.

Le sujet de la gestion de l'eau en tant que patrimoine culturel constitue souvent un nouveau champ de recherche, très ouvert, à l'intersection de divers domaines académiques liés aux sciences exactes et aux sciences sociales : hydrologie, géographie, archéologie, agronomie, génie civil, conservation du patrimoine, histoire, anthropologie, etc. Il faut donc envisager une approche pluridisciplinaire, tant des synthèses régionales que pour développer les études de cas. En conséquence, la demande de l'ICOMOS aux auteurs était de les encourager à aller au-delà de leurs compétences classiques, de les prolonger par une nouvelle réflexion, en particulier pour la compréhension du patrimoine matériel de la gestion de l'eau, sa conservation et sa présentation aux générations actuelles. Cet effort pour promouvoir de nouveaux points de vue sur la compréhension du patrimoine constitue une facette importante de ce programme d'étude. Le groupe des auteurs réunis montre l'effort réalisé dans cette voie, mais aussi la difficulté du travail qui leur a été demandé.

Les résultats obtenus montrent que la nouveauté du sujet de la gestion de l'eau en tant que patrimoine cultuel et en tant qu'exemples de développement durable de sociétés anciennes est une prise de conscience assez variable d'un pays à un autre, d'un sujet à l'autre. Il n'est pas rare que le patrimoine de la gestion de l'eau soit négligé pour un ensemble de raisons cumulatives. En effet, il n'est pas toujours spectaculaire et son caractère vernaculaire et répétitif le fait parfois juger de faible importance. Très souvent, il est encore utilisé dans un état mixte, entre structure traditionnelle et modernisation technique qui tend à effacer sa perception patrimoniale. Dans d'autres cas, la connaissance de ce patrimoine est essentiellement historique et culturelle, c'est-à-dire qu'elle repose sur des données à dominante sociale et mémorielle. Mais nous avons constaté que dans de nombreuses régions et pays, l'identification, l'étude et la protection de ces patrimoines était apparue et avait fait des progrès rapides. La prise de conscience a eu lieu d'un patrimoine allant au-delà du patrimoine classique des monuments, des sites et des centres urbains. Il n'y a d'ailleurs pas de contradiction entre ces deux lectures de la notion de patrimoine, car elles peuvent se compléter d'une manière remarquable, tout particulièrement dans cette région du monde où de magnifiques exemples de cette conjonction existent en nombre. Un patrimoine à caractère technique et fonctionnel a donc toute sa place aujourd'hui dans les propositions qui peuvent être faites pour les reconnaître et les mettre en valeur. Le patrimoine de la gestion de l'eau doit entrer maintenant comme un élément majeur dans les processus d'analyse et d'étude des vestiges matériels. Il rejoint également les préoccupations de développement durable, car il apporte très directement des exemples de la manière dont nos ancêtres ont conçu, réalisé et utilisé la ressource vitale de l'eau. Enfin, notamment dans les régions humides subtropicales étudiées, les surfaces de l'eau domestiquée constituent un attribut majeur de nombreux paysages culturels, auxquels il donne d'incomparables qualités d'étendue, de perspective et d'esthétique.

Rappelons que pour entrer pleinement dans le champ de la Convention du patrimoine mondial de 1972, nous devons partir d'un patrimoine matériel bien conservé, dans un état d'intégrité et d'authenticité suffisants. Mais il est aussi possible d'envisager la conservation de traditions et de représentations dans le domaine de la gestion de l'eau comme appartenant au domaine de la Convention du patrimoine immatériel de 2003.

Comme dans les autres catégories de patrimoine, nous trouvons la distinction entre des patrimoines à caractère archéologique et des patrimoines encore fonctionnels. Les premiers ont généralement perdu toute fonctionnalité et se présentent à l'état de vestiges matériels in situ *plus ou moins complets. Leur évaluation et leur conservation rejoint celle des sites archéologiques. Les seconds posent assez généralement la question de leur évolution et de leur adaptation moderne, ce qui affecte souvent leur intégrité et leur authenticité par les matériaux utilisés, les changements structurels et de dimensions, l'apport de moyens mécaniques, etc. Cependant, il faut souligner que ces efforts de modernisation conservent la fonctionnalité hydraulique, souvent l'amplifient, ce qui peut être considéré comme la conservation d'une forme de l'intégrité (l'intégrité fonctionnelle) et de l'authenticité (l'authenticité d'usage). Il convient donc d'apprécier en quoi et comment interviennent ces modifications apportées par le monde moderne et les technologies industrielles. Il convient d'apprécier comment les conceptions initiales et les usages de longue durée du passé ont été conservés, en quoi ils sont encore lisibles dans un site et un environnement donné, comment l'esprit initial perdure ou au contraire a été trop radicalement perturbé pour être encore reconnaissable. Le challenge ainsi posé nous semble plus délicat à résoudre que dans bien des cas de sites patrimoniaux classiques, les enjeux encore plus forts entre témoignages du passé et projets du futur.*

Ce qui est vraiment très important dans cet ensemble régional d'Extrême Orient et d'Asie du Sud-Est, c'est la gestion multimillénaire de l'eau pour la culture du riz, et cela dans toutes les conditions géographiques : plaines, deltas fluviaux ou montagnes; et sous toutes les latitudes des régions subtropicales étudiées. On savait cela en tant que fait civilisationnel fondamental, bien entendu, mais c'est l'approche patrimoniale de ces données, depuis quelques années, qui constitue quelque chose de nouveau. Des reconnaissances existent déjà de ces paysages culturels, d'autres se préparent, des *programmes de gestion et de valorisation sont en cours. Ces patrimoines ont des racines incroyablement anciennes dans nombre de cas, montrant l'ingéniosité de l'Homme et ses efforts collectifs pour maîtriser, conserver et utiliser l'eau au profit de la vie durable des sociétés humaines. Ils atteignent à leur apogée des dimensions incroyablement vastes, multipliant les digues, les bassins réservoirs, les canaux artificiels, les terrasses. Ils requièrent des connaissances d'observation, de déduction rationnelle, d'anticipation, de calculs qui forment une science pratique et une technologie hydraulique toutes deux remarquables, transmises par la pratique. Le patrimoine de la gestion de l'eau concerne le transport et pour cela la construction de canaux artificiels, dans lesquels cette région du monde a été pionnière, complétant ainsi, en les reliant, les rivières et les étendues d'eau naturelles. Par ailleurs, l'Homme a appris à se protéger du débordement des eaux, par des digues et des travaux parfois extrêmement ingénieux. Les recherches archéologiques dans le domaine ne cessent d'étonner, apportant des témoignages précieux sur les savoir-faire développés dans ce but, pour faire face aux déchaînements de la nature et à ses possibles effets destructeurs. Enfin, ces patrimoines de l'eau peuvent être lus à des échelles territoriales plus fines par les études de cas, celle de communautés locales, d'une ville ou d'un village. Ils apportent alors des exemples des plus probants de l'organisation sociale structurée autour de la gestion de l'eau et, au-delà, des représentations, des traditions et des croyances associées aux différentes manifestations de l'eau dans la vie humaine.*

Pour terminer cette brève conclusion, nous tenons par-dessus tout à remercier chaleureusement les auteurs pour le temps consacré à leur participation à cette Étude thématique. C'est vraiment important pour ICOMOS de pouvoir compter sur une telle disponibilité. Nous remercions également chaleureusement toutes les personnes qui se sont impliquées dans cette étude thématique avec le support du Secrétariat International d'ICOMOS à Paris, plus spécialement Nupur Prothi et à sa suite Pierre-François Toulze pour la gestion des auteurs et des textes, Lucile Smirnov et à sa suite Angélique Ploteau du centre de documentation d'ICOMOS. Nos remerciements vont également à Marie-Laure Lavenir, directrice d'ICOMOS qui a assuré l'organisation matérielle et la coordination administrative de l'étude, sans lesquelles rien n'aurait pu advenir. Il en va de même pour l'implication des comités nationaux de l'ICOMOS, notamment de Corée, de Chine et du Japon, qui ont joué un rôle décisif dans la recherche des auteurs les plus à même de répondre à nos attentes.

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The 'Bull God', an ancient deity symbolising the power of the waters on an island in China's Grand Canal near Yangzhou / *Le "Dieu Taureau", une ancienne divinité qui symbolise la puissance des eaux dans une île du Grand Canal de Chine, près de Yangzhou © Michel Cotte – ICOMOS, 2015.*

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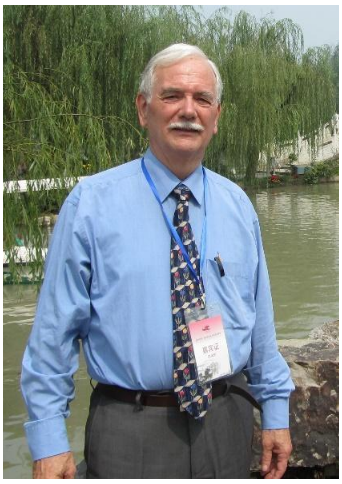
Michel J. Cotte



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He has worked in these fields as an expert for ICOMOS since the middle of the 1990s, and later as an adviser evaluating the World Heritage dossiers. He is presently an expert member of the ICOMOS World Heritage Panel. From the 2000s, he has also directed important Thematic Studies for ICOMOS in the field of Heritage Science and Technology.
The approximate 200 scientific articles, official reports and many books he has written or directed include:

- Michel Cotte and Clive Ruggles (dir.), *Heritage Sites of Astronomy and Archaeoastronomy in the context of the UNESCO World Heritage Convention*, *ICOMOS & IAU Thematic Study*, Paris, ICOMOS & IAU, vol 1, 2010 and vol. 2, 2017.
- *Cultural Heritage of Water / Les patrimoines culturels de l'eau, Thematic Study (I): Middle East and Maghreb / Moyen-Orient et Maghreb*, Paris, ICOMOS, 2015.

LI Haijing

LI Haijing PhD is an Associate Professor in Zhejiang University of Water Resources and Electric Power, Hangzhou, China. She mainly focuses on the history of water and the spread of western water conservancy science and technology in China. She received her PhD in the History of Science and Technology from the University of Science and Technology of China. She was a visiting scholar in The Needham Research Institute (NRI) funded by the New York Lee Foundation in 2018. She has presided over, and participated in more than 10 provincial and ministerial-level projects, and published more than 20 academic papers and 2 monographs.

Yasuhiro Honda

Yasuhiro Honda is an Associate Professor of the Department of Civil Engineering at Daiichi Institute of Technology in Kagoshima, Japan. He is a member of the committee of the History of Civil Engineering of the Japan Society of Civil Engineering. His work focuses mainly on the history of bridge construction in Japan and in France. For his postgraduate thesis, he worked on the political and economic analysis of the construction of the Tsujunkyo Aqueduct at the Graduate School of Kumamoto University. As an exchange student, from 2001–2003, he studied bridge construction strategy of the Hennebique, an early French construction company for which he received a doctoral degree from Kumamoto University. In 2009–2010, he worked on the historical French timber bridge with a comparative analysis of Japanese timber bridges in the Centre François Viète at Nantes University as a researcher on a French government scholarship.

Takashi Itoh

Born in 1945, Takashi Itoh pursued a doctoral degree at the University of Tokyo, earning his PhD in Engineering in 1978. Currently, he is Chief Researcher at the Industrial Heritage Information Center, Chief of the Technical Heritage Subcommittee of Japan ICOMOS, TICCIH Member, a Director of the Japan Industrial Archaeology Society (former President), Member of the Council of Experts on Industrial Heritage including Working Assets of the Cabinet Office and a NPO Leader of ‘Let’s Open Kachidoki Bridge’.

Takashi Itoh has published numerous articles in English including:

- Renovation of two Docks from the viewpoint of authenticity and integrity – Creative preservation: Japan and Denmark examples – ‘CONGRESO XVII TICCIH-CHILE’ (pp. 691–696, 2018),

- Principles for conservation and restoration of modern cultural heritage – Interpretation through adaptive-use of industrial heritage properties –, 'Principles for conservation and restoration of modern cultural heritage properties', Tokyo National Research Institute for Cultural Properties (pp. 22–41, 2017),
- Keynote Paper 'The conservation movement of historic heritage in Japan – Past, present and future? (1960-2012+α)', TICCIH Series 2, TICCIH CONGRESS 2012 (pp. 41–55).

Eun-sol Koh

Ms Eun-sol Koh has worked as a researcher at the Center for Jeju Studies in the Jeju Special Self-Governing Province. At the centre, she has been mainly involved with a series of research projects on Sea Women called Jeju Haenyeo whose traditional culture was inscribed as World Intangible Heritage. She acquired a bachelor's degree from the Korea National University of Cultural Heritage in 2015 and in 2018 was awarded a master's degree in Legal Policy for Cultural Heritage from the same school. She has been a PhD student at the Geography Department, Jeju National University since 2018.

Ya-wen Ku

Ya-wen Ku currently works as an Associate Research Fellow at Taiwan History Institute, Academia Sinica, Chinese Taipei. She earned her PhD from Yokohama National University, Japan. Her research interests lie in the field of East Asian environmental history (in particular disease and water), as well as historical GIS. Her recent research projects focus on rural water culture, and the history of dams in Chinese Taipei. Some of her recent publications include: *Charting the Rivers: Maps of the River Investigation and Regulation in Colonial Taiwan* (2017); 'Taming the Blind Snake: Flooding Disasters and River Regulation of the Zengwen River in Colonial Taiwan,' in *Landscape Changes and Resources Utilization in East Asia* (2018); 'Floods and Governance: The Historical Construction of Vulnerability in Taiwan under Japanese Rule,' in *Hydraulic Societies: Water, Power, and Control in Eurasian History* (forthcoming).

Yuxin Li

Li Yuxin, is an assistant research fellow at the Chinese Academy of Cultural Heritage. Her research interests are world cultural heritage, agricultural cultural heritage and cultural heritage management. She has been involved in writing the nomination dossier and OUV research on China's Tentative List for World Cultural Heritage, such as the Maritime Silk Road Sites in China, Diaoyucheng Fortress, Mining and Metallurgy Sites in Huangshi. She has also conducted sustainable development case studies of the Honghe Hani Rice Terraces (HHRT) and Lijiang Ancient Town which are on the World Heritage List. As a team member, she participated in China's fieldwork in HHRT of 'Culture-Nature Connecting Practice' Phase III, which was carried out jointly by ICOMOS, IUCN and GIAHS in 2019. Inspired by the project, she proposed research on heritage resource conservation and management from the perspective of culture and nature.

Szu-Ling Lin

Professor Lin earned her PhD in the Department of Architecture, National Chen Kung University, Chinese Taipei. She also received a second master's degree from the Department of Economics, National Taiwan University, Chinese Taipei. Her works focus on historic conservation of cultural heritage. She is also a member of US ICOMOS, the Architectural Institute of the Republic of China, and the Society of Architectural Historians of Taiwan. She is leading research projects funded by the Ministry of Science and Technology and managing several investigations of historic conservation for the Government since 2007. Her recent research interest is the dual relation between tangible cultural heritage and sustainability in historic urbans and creative cities. She aims to theorise and practice how tangible cultural heritage and its conservation evolve sustainably, and affect the sustainability of cities, as social, economical, environmental and cultural capital.

Guo Na

Guo Na, associate professor in Yunnan Academy of Social Sciences, is an ecological anthropologist who explores the interrelationship and integration between natural ecosystems and socio-cultural systems. Her research interests include: water culture of ethnic groups in mountainous Southwest China, construction of national parks and nature reserves, and sustainable natural resource management. In recent years, she has conducted more research on environmental justice, hoping to promote more just natural resource management and community development in China.

Ho Ngoc Son

Dr Ho Ngoc Son is currently Professor of Climate change and Indigenous knowledge at Thai Nguyen University of Agriculture and Forestry. He obtained a master's degree in Forestry (2004) and a PhD in Global Environmental Change (2013) from the Australian National University. He has published several peer-reviewed articles on Indigenous knowledge and climate change adaptation of ethnic minority people in Vietnam. In addition to research and teaching university students, Dr Son has worked as Deputy Director of the Agriculture and Forestry Research and Development Centre for Mountainous Region (ADC) in Thai Nguyen province where he has led many development projects. All these projects aim at promoting the equality, rights and voices and empowerment for ethnic minority women in remote areas of Vietnam. His work aims to ensure that vulnerable people are empowered to achieve their fullest potential so as to lead their lives in an equal, inclusive and progressive society.

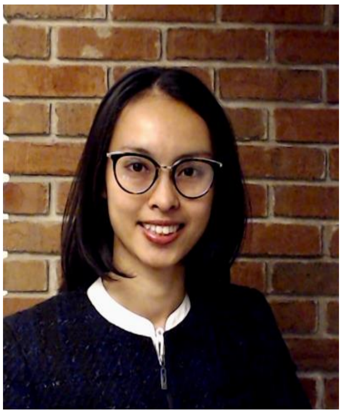
Zhang Nianqiang

Nianqiang Zhang is a Professor of the Engineering Technology Research Center for flood control, drought relief and disaster reduction of the Ministry of Water Resources and specialises in flood management, the history of flood and drought disasters and the protection of ancient water projects.

Won-Bae Park

Dr Won-Bae Park received his PhD degree from Nagasaki University and has been working as a senior research fellow in Jeju Research Institute since 1999. His research focuses on water resource management policy which includes establishing the management and protection plan of Jeju's groundwater. He is also coordinating and writing 'Jeju's regional water stories' to inherit and develop the heritage of Jeju's water.

Hieu Phung



Hieu Phung (PhD, University of Hawaii) is an environmental historian of Vietnam at the University of Michigan Center for Southeast Asia Studies. She is also affiliated with the University of Hawaii (2020–2022) and The Ohio State University (2019–2021). Her research focuses on the historical agency of water and climate in stimulating social and political change. In pursuing environmental history, she makes extensive use of traditional maps and texts that reveal the production of geographical knowledge. She is working on a book project entitled *The Realization of a Water Space: An Environmental History of Early Modern Vietnam*. Her recent article, 'Naming the Red River – Becoming a Vietnamese river,' was published by the *Journal of Southeast Asian Studies* last December.

Nupur Prothi

Nupur Prothi is an urban planner and cultural landscape professional. As an International Board member of ICOMOS and Vice-President (Asia and the Pacific) of their newly formed International Scientific Committee on Water and Heritage, she is committed to pivoting water innovation within a larger heritage context. As a practitioner and part-time academic she has been an adviser on water-related projects to various national and international authorities and institutions. She translates her cultural landscape experience through nature and culture-based solutions to urban infrastructure projects through her start-up and foundation 'Beyond Built' in India.

Jiang Rui

Jiang Rui, born in 1976, is deputy director of Chongqing Baiheliang Underwater Museum, a member of the China Water Culture Expert Committee and a member of Chongqing Cultural Tourism Standardisation Committee. His main research fields are the protection, exhibition and sustainable development of the Baiheliang Hydrological Inscription, and the preventive protection monitoring of water heritage. He was part of the team involved in the application of the Baiheliang Hydrological Inscription for China's national water heritage and world cultural heritage, and was also involved in compiling the exhibition outline of the China Hydrological Museum.

Je-Hun Ryu

Dr Je-Hun Ryu has been an endowed-chair professor at the Korea National University of Cultural Heritage since March 2018 and is the author of *Reading the Korean Cultural Landscape* (2000; 2010). He was a faculty member of the Department of Geography, Korea National University of Education from September 1987 to February 2018. He was a Fulbright professor and lecturer to the Department of East Asian Languages and Cultures, and Department of Geography, UCLA from 2002 to 2004. In August 2020, he began his four-year term as Chair for the IGU (International Geographical Union) Commission on the Cultural Approach in Geography. He has also served as President of the Korean Association for Studies on Heritage Landscapes since June 2018. From 2011 to 2017, he served on the National Committee for Cultural Heritage Administration in Korea. His research interest has expanded into Heritage Studies and Management beyond the scope of Cultural and Historical Geography. Consequently, he has been acting as a contributing member for the ICOMOS-IFLA International Scientific Committee on Cultural Landscapes since August 2019.

Hatthaya Siriphatthanakun

Hatthaya Siriphatthanakun is currently a specialist in cultural heritage conservation at the Southeast Asian Ministers of Education Organization Regional Center for Archaeology and Fine Arts (SEAMEO SPAFA). She is responsible for professional development on cultural heritage conservation for 11 member countries in Southeast Asia through training, seminars, and research. With over 17 years' experience at many of Thailand's governmental agencies, she has developed as a conservation professional and expanded her network as a conservation landscape architect. In addition to her conservation practice, she has worked as a consultant on conservation projects and coordinated several regional activities in collaboration with various international organisations. Since 2007, she has been involved in Thailand's Memory of the World Programme and World Cultural Heritage. Apart from a bachelor's degree in landscape architecture, Ms Siriphatthanakun received her master's degree in Conservation Studies from the University of York, UK, and is now conducting research at the PhD level focusing on water management in ancient cities. She was elected as an ICOMOS Board member for the periods 2018–2020 and 2021–2023.

Fei Tang

Professor Fei Tang is the director of Sichuan Province Institute of Cultural Relics and Archaeology, China. He also serves as a deputy standing director at the Committee for the Conservation and Research of Cultural Routes, ICOMOS China. He is an expert on planning and historical building preservation at the National Cultural Heritage Administration of China, a member of the Expert Committee for the Conservation of China's Historical Cities, Towns and Villages, and a member of the Expert Committee for World Heritages in Sichuan Province. Currently, he is in overall charge of archaeological excavations at the Sanxingdui site and is responsible for the preservation and display of the cultural relics unearthed.

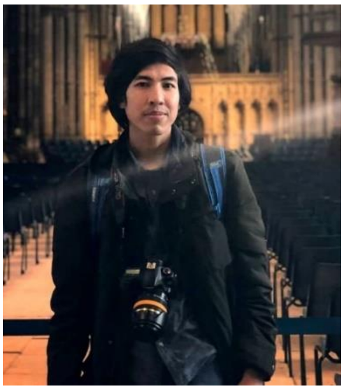
Geng Tao

Geng Tao, born in 1968, is deputy secretary of the Party Committee of Shaanxi Provincial Water Resources Department, and a member of the China Water Culture Expert Committee and the Water History Expert Committee. His main interests lie in spiritual civilisation construction, value excavation, basic research, protection and utilisation of water cultural heritage, and publicity and education in water culture. He presided over the *Development Plan of Water Culture in Shaanxi Province* and the *Protection and Utilisation Plan of Water Cultural Heritage in Shaanxi Province*. He has edited and published more than 10 books on water culture, including *Shaanxi Water Cultural Heritage List*, *Shaanxi River History*, *On-the-spot Report on Water Conservancy in Shaanxi-Gansu-Ningxia Border Region during Yan 'an Period.*

Cheh-Shyh Ting

Cheh-Shyh Ting serves as a Distinguished Professor, specialising in Hydrogeology, at the Department of Civil Engineering and Director of the Centre for Water Resources Education and Studies, National Pingtung University of Science and Technology. He received his Diploma on Hydraulic Engineering at IHE-Delft (International Institution for Infrastructural, Hydraulic and Environmental Engineering) in the Netherlands in 1986 and his MSc and PhD on Hydrogeology from Free University, Amsterdam, the Netherlands, in 1993 and 1997, respectively. Prof. Dr Ting is the author of two books and over 300 technical papers in the field of groundwater hydrology, resources evaluation and management, artificial recharger, HydroGeoEcology and Water heritage. He is actively involved in research works and consulting with government agencies, as well as consulting firms specialising in the study region of Pingtung Plain, Chinese Taipei.

Theerasak Thanusilp



Theerasak Thanusilp is an archaeologist, from the Archaeology Department, Fine arts Department of the Ministry of Culture of Thailand. From 2015 to 2020, he was responsible for archaeological research and conservation projects in Tak and Sukhothai Province, and was responsible for research planning and excavation in Ban Wang Hat, Lamphan River Basin, between 2015 and 2018. He also conducted field surveys of Pre-Sukhothai sites (ninth to twelfth century) for the Heritage and Conservation Administration at Sukhothai UNESCO Heritage Site.

Chen Tongbin

Chen Tongbin is chief planner at the China Architecture Design & Research Group. She is Honorary Director of the Institute of Architectural History and Director of SACH's Key Scientific Research Base on Conservation Planning for Cultural Heritage. She is a member of the Expert Group of the State Administration of Cultural Heritage Consultation Center and Vice-President of the Chinese Society of Cultural Relics. She is also a former vice-president of ICOMOS China (member of the Disaster Prevention Professional Committee and member of the Cultural Route Professional Committee of ICOMOS). Her main interests lie in value research and conservation planning of world cultural heritage and large-scale archaeological sites in China and has chaired the work of conservation master planning of many major world cultural heritage sites in China, such as the Forbidden City, the Great Wall, Mogao Caves. She also successfully chaired the work for many sites in China in their successful nomination for the World Cultural Heritage list, such as the West Lake Cultural Landscape of Hangzhou, Site of Xanadu, Silk Roads: the Routes Network of Chang'an-Tianshan Corridor and the Archaeological Ruins of Liangzhu City.

Pierre-François Toulze

Pierre-François Toulze studied history and journalism in Paris and obtained a master's degree in political science from IEP, Lyon. He now works as an independent consultant, specialising in cultural heritage, particularly in the implementation of the World Heritage Convention. He is a member of ICOMOS France and of the International Cultural Tourism Committee (ICTC), the international scientific committee of ICOMOS on cultural tourism.

Le Anh Tuan

Dr Le Anh Tuan has been working at Can Tho University since 1982 and currently holds the position of senior lecturer at the College of Environment and Natural Resources, Can Tho University, Vietnam. He is also the former vice-director of the Research Institute for Climate Change – Can Tho University, Vietnam. He holds a PhD in Applied BioSciences and Engineering, and specialised in Environmental Hydrology at the Catholic University of Leuven, Belgium.

Dr Tuan has many years of experience in teaching and research in the fields of water environment, climate change, constructed wetlands, water supply, natural disaster prevention and preparation, and rural development projects. From 1993 to 1999, he worked in Champasak province as an engineering expert for the implementation of irrigation systems and water supply stations in a rural development project. In the Mekong River Delta, he was engaged in many water management, climate change adaptation, environmental education and rural development programmes and participated in research projects involving climate change and adaptation.

Bui Tuan Tuan

Bui Tuan Tuan, from Thai Nguyen University of Agriculture and Forestry, in Vietnam, is an expert in the management of water resources, climate change response, and the management of natural resources He has worked for more than 10 years as a senior researcher and as a project manager in related fields for over 5 years. He is a graduate of Flinders University (College of Science and Engineering) in Australia.

Zhao-Zong Wu

Zhao-Zong Wu currently works as an assistant research fellow at Taiwan International Institute for Water Education (TIIWE), Chinese Taipei. His research interests lie in the field of the culture and history of the region of Taiwan history during the Japanese colonial rule period (1910–1945), as well as the cultural heritage of Chinese Taipei (in industrial and water). Recent research projects focus on the water heritage of rivers of the island of Taiwan. Some of his recent publications include: ‘A Brief Study of the Taiwan Water Culture System,’ (co-authored with Sinite-C Yu, Wen-Yao Hsu, Yu-Hsing Wang, Chia-Ying Wu, Ching-Mei Lin) *Journal of Cultural Heritage Conservation* (No. 55, 2020.03); ‘An Overview on World Water Heritage System – Sekikawa Suikei Land Improvement District, Japan,’ *Asian Network of Industrial Heritage Bulletin* (3rd Issue, 2019,12)

Wang Yinghua

Wang Yinghua PhD, is a Professor at the China Academy of Water Resources and Hydropower Sciences and works mainly on research of water conservancy history, the protection and utilisation of water heritage, research of regional water culture development strategy, as well as the planning and content design of water-related museums. She has published four works on the history of China's water conservancy.

Sinite Yu

Sinite Yu is Director of Education, Research and Development at the Taiwan International Institute for Water Education (TIIWE) and was Assistant Professor at National Chiayi University and Huafan University and research fellow at the Ecological Engineering Research Center and Disaster Prevention Research Center of National Taiwan University. He specialises in the integration of water and land resources planning and management, ecological engineering, management of water conservancy and flood control, wetland restoration, natural water treatment, and water heritage evaluation.

Xu Zhaoping

Xu Zhaoping, born in 1977, is director of the Huai 'an Branch Office of Jiangsu Hydrology and Water Resources Survey Bureau. She is mainly engaged in hydrological survey, water resources management, heritage promotion and development of regional water culture etc.

Table of illustrations

Cover illustrations

Images of authors

02. South Korea

Regional overview: Water and heritage on Jejudo Island: An evolutionary process in the conservation and use of spring water

Fig. 1: Distribution pattern of springs on Jejudo Island (2013-2014).
Fig. 2: The pattern of water use and settlement morphology in the 1930s.
Fig. 3: Plan of Gusimul.
Fig. 4: Gusimul.
Fig. 5: Gusimul.
Fig. 6: Gusimul.
Fig. 7: Gusimul.
Fig. 8: Gusimul.
Fig. 9: Plan of Onseongmul.
Fig. 10: Ongseongmul.
Fig. 11: Plan of Sowangmul.
Fig. 12: Sowangmul.
Fig. 13: Sowangmul.
Fig. 14: Sowangmul.
Fig. 15: Yusuamcheon.
Fig. 16: Yusuamcheon.

Case study: The sustainable conservation and use of living properties: the case of the village called Jocheonri

Fig. 1: Ken-mul on the front and Jocheonjinseong Walls and Hallasan Mountain in the background.
Fig. 2: The Function and use of spring water before and after the 1980s.
Fig. 3: Jejujari-mul and the alley leading to its entrance.
Fig. 4: Locations of spring waters in Jocheonri Village (2019).
Fig. 5: Trails to explore the sites of spring water in Jocheonri Village (2020).

03. Japan

Regional overview: Water Heritage in West Japan

Fig. 1: Climate Classification of Japan.
Fig. 2: Geological tectonic line and granitic distribution map of West Japan.
Fig. 3: Drinking water through time. © *Takashi Itoh*.
Fig. 4: Irrigation Water through time. © *Takashi Itoh.*
Fig. 5: Agriculture and Forestry Facilities through time. © *Takashi Itoh.*
Fig. 6: Water used for transportation through time. © *Takashi Itoh*
Fig. 7: Water and power through time. © *Takashi Itoh.*
Fig. 8: Water and defense trough time. © *Takashi Itoh.*
Fig. 9: Water used for Health and Recreation through time. © *Takashi Itoh.*
Fig. 10: Flood control through time. © *Takashi Itoh.*
Fig. 11: Water and Familiarity through time. © *Takashi Itoh.*
Fig. 12: Water and religion through time. © *Takashi Itoh.*
Fig. 13: Water and bridges through time. © *Takashi Itoh.*

Fig. 14: A group of stone bridges of Midorikawa (Kumamoto Pref.) – The scenery of continuous stone arch bridges in rural area. © *Kazuyuki Yano.*
Fig. 15: Shimanto River (Kōchi Pref) – Cultural lifestyle by Clear River. © *Kazuyuki Yano.*
Fig. 16: Sluice gate in Yatsushiro Polder (Kumamoto Pref.). © *Kazuyuki Yano.*
Fig. 17: Water network. © *Takashi Itoh.*
Fig. 18: Yanagawa (Fukuoka Pref.) – The scenery of a creek and the castle's moat. © *Kazuyuki Yano.*
Fig. 19: Water system in cities through time. © *Takashi Itoh.*
Fig. 20: Catchment basin. © *Takashi Itoh.*
Fig. 21: Water systems in regions. © *Takashi Itoh.*
Fig. 22: Covered bridge (Ehime Pref.). A bridge for supporting life in mountainous regions. © *Kazuyuki Yano.*
Fig. 23: Shikinaen – (Okinawa Pref.) A landscape garden where the culture of Ryukyu, Japan and China are fused. © *Kazuyuki Yano*.
Fig. 24: Wasabi farm (Shizuoka Pref.) – Wasabi farm that is supported by spring water. © *Kazuyuki Yano.*
Fig. 25**:** Lotus farm (Chiba Pref.). © *Kazuyuki Yano.*
Fig. 26: Junsai pond (Akita Pref.) – Junsai – (water shield aquatic plant) farm. © *Kazuyuki Yano.*
Fig. 27: Mogami River (Yamagata Pref.) Rivers that have supported rice farming and distribution. © *Kazuyuki Yano.*
Fig. 28: Daimyo Garden (Gunma Pref.) –landscape garden that is nurtured by Samurai culture. © *Kazuyuki Yano.*
Fig. 29: Shibai-zeki (Kagoshima Pref.) – a dam made with tree branches. © *Kazuyuki Yano.*

Case study: Aqueduct and hydraulic system of Tsujun irrigation canal (Kyushu, Japan)

Fig. 1: Rice fields of the Shiraito Plateau. © *Yasuhiro Honda.*
Fig. 2: Shiraito Plateau and irrigation canals (*Modified from Koga et al., 2010*).
Fig. 3: Tsujunkyo Aqueduct Bridge showing its spectacular water discharge. The Shiraito Plateau forms the background of the aqueduct. © *Yasuhiro Honda.*
Fig. 4: Spillway made with original materials. © *Yasuhiro Honda.*
Fig. 5: Circular tank diversion*.* © *Yasuhiro Honda.*

04. China: General overview

Fig. 1: Schematic diagram of the distribution of water heritage in tropical and subtropical areas of China (The region in the figure is not the complete extent). © *Zhang Nianqiang*.
Fig. 2: Baiheliang Inscription from Hydrologic Inscription Cultural Relics in Three Gorges Reservoir Area.
Fig. 3: Schematic diagram of the relationship between stone fish and inscribed water level. From Hydrologic Inscription Cultural Relics in Three Gorges Reservoir Area.
Fig. 4: Schematic diagram of the change of water level elevation of Baiheliang recorded from 634 to 1963.
Fig. 5: Taihu Lougang Polder Fields in Huzhou County, Zhejiang Province, in 2019. © *Wei Jianguo, Wang Ying.*
Figs. 6-7: Tashan Weir and its overflow dam, in 2019. © *Wei Jianguo / Wang Ying.*
Fig. 8: Honghe Hani Terraces, in 2018. © *Zheng Yubao*.
Fig. 9: Schematic diagram of spatial structure of Honghe Hani Terraces.
Fig. 10: The ditch used for raising fish in terrace fields, in 2018. © *Zheng Yubao.*
Fig. 11: The huts used as well houses in terrace fields, in 2018. © *Zheng Yubao.*
Fig. 12: Stacked farmland in Xinghua, in 2019. © *Xu Xiaofeng.*
Fig. 13: Schematic diagram of basic ecological principles of mulberry fish pond.

05. China: Southern China

Regional overview: Cultural heritages of water management in the southern coast of China

Fig. 1: Photos of Sangyuanwei in Nanhai County in 2019. © *Liu Lizhi.*
Fig. 2a: Big and Small Tianping in 2002. © *Wang Lili, FOTOE.*
Fig. 2b: Big and Small Tianping when passing water, in 2005. © *Qin Jiangying, FOTOE.*
Fig. 3: Nandou sluice gate, in 2015.
Fig. 4: Sangji fishing pond in Jun'an Town, Shunde County, Guangdong Province, in 2005. © *Ange, FOTO.*

Case study: Water Heritage of Hani Rice Terraces, with a Special Focus on UNESCO World Heritage Property

Fig. 1: Distribution map of villages in nominated property and buffer zone *(Nomination File, 2003).*
Fig. 2: The landscape pattern of 'Forest-Village-Terrace-River'. *(Nomination File, 2003).*
Fig. 3: The landscape of Hani Rice Terraces. © *Li Yuxin.*
Fig. 4a-4b: Vertical flow of water among paddy fields. © *Li Yuxin.*
Fig. 5a-5b: Nodes of a village with water heritage in Dayutang Village. © *Li Yuxin.*
Fig. 6a-6b: Water Woods and canals to distribute water in Yakou Village. © *Li Yuxin.*

06. China: Central China

Regional overview: Central China of Yangtze River

Fig. 1: A map of the Central China Yangtze River: (1) Fushou ditch site, (2) Hydrological inscriptions along the Yangtze River, (3) Polder field irrigation project of Dongting Lake, (4) Ziquejie Terrace, (5) Changqu Channel irrigation engineering system, (6) Chatanbei pond irrigation engineering system, (7) Qianjin pond irrigation engineering system, (8) Flood wall of Shouxian Old City, (9) Flood control system of Jingjiang Levee, (10) Quebei irrigation engineering system. © *Zhang Nianqiang.*
Fig. 2: 'Thunder Hole' reef and its inscription, taken from *Selections of the Inscription in the Three Gorges Dam, Hubei.* © *Changjiang Water Resources Commission of the Ministry of Water Resources.*
Fig. 3a-3b: Borrowing fields for water conveyance: terraced fields are also water channels. © *Wei Jianguo & Wang Ying*
Fig. 4: Changqu Channel. © *Liu Jiangang.*
Fig. 5: Chatanbei Pond. © *Liu Jiangang.*
Figs. 6a-6b: The East gate and Urn City of Shouxian Old City. (a) Outside (b) inside (Urn City). © *Zhang Nianqiang.*
Figs. 7a-7b: The whole view of the culvert and a schematic diagram of its operation principle. © *Zhang Nianqiang.*

Case study: Dujiangyan Irrigation System

Fig. 1: Location of Dujiangyan Irrigation system. © *He Ting.*
Fig. 2: Dujiangyan Irrigation Area. © *He Ting.*
Fig. 3: Yuzui Bypass Dike. © *Xu Jun.*
Fig. 4: Feishayan Floodgate. © *Xu Jun.*
Fig. 5: Baopingkou and Lidui Platform. © *Xu Jun.*
Fig. 6: Plan of Dujiangyan Irrigation System. © *He Ting.*

07. China: Eastern coast

Case study: The peripheral water conservancy system in the archaeological ruins of Liangzhu City

Fig. 1: Topographic and geomorphic map of the Archaeological Ruins of Liangzhu City. © *Institute of Architectural History, China Architecture Design & Research Group).*
Fig. 2: Aerial view of the west group of High-dam at the Mouth of the valley. © *Zhejiang Provincial Institute of Cultural Relics and Archaeology.*
Fig. 3: Grass-wrapped silt structure and details of Laohuling Site. © *Institute of Architectural History, China Architecture Design & Research Group.*

08. China: The Grand Canal

Regional overview: The Grand Canal of China

Fig. 1: The general settlement of the Grand Canal in China. © *The Grand Canal, World Heritage nomination dossier.*
Fig. 2: Southern part of the Grand Canal's heritage: Zhedong (ZD) and Jiangnan (JN) sections. © *The Grand Canal, World Heritage nomination dossier.*
Figs. 3-4: Zedong canal: the Bazi Bridge and the canal banks in Hangzhou. © *The Grand Canal, World Heritage nomination dossier.*
Fig. 5: Suzhou: Baodai Bridge. © *The Grand Canal, World Heritage nomination dossier.*
Fig. 6: Grand Canal crossing the modern city of Changzhou. © *The Grand Canal, World Heritage nomination dossier.*
Fig. 7: Central south-eastern part of the Grand Canal: Huaiyang or Li Canal section (HY) and Zhong (ZH) section. © *The Grand Canal, World Heritage nomination dossier.*
Fig. 8: Archaeological site of the Caoyun Governor's Mansion. © *The Grand Canal, World Heritage nomination dossier.*
Fig. 9: Qingkou – Hongze Lake and dike. © *The Grand Canal, World Heritage nomination dossier.*
Fig. 10: Zhong canal. © *The Grand Canal, World Heritage nomination dossier.*
Fig. 11: Central-western part of the Grand Canal: Tongji (TJ) and Wei or Yongji (WH) sections. © *The Grand Canal, World Heritage nomination dossier.*
Fig. 12: Tongji Canal is an archaeological heritage in Luizi, but the bridge and canal banks are still functional. © *The Grand Canal, World Heritage nomination dossier.*
Fig. 13: Archaeological site of a large granary related to the Grand Canal commercial function, Wei Canal. © *The Grand Canal, World Heritage nomination dossier.*
Fig. 14: Nanwang, the Daicun dam. © *The Grand Canal, World Heritage nomination dossier.*
Fig. 15: Central North-Eastern part of Grand Canal: Huitong and Nan sections. © *The Grand Canal, World Heritage nomination dossier.*
Fig. 16: Archaeological dike of the canal made of bricks. © *The Grand Canal, World Heritage nomination dossier.*
Fig. 17: Northern part of Grand Canal: Bei (BY) and Tonghui (TH) sections.
© *The Grand Canal, World Heritage nomination dossier.*
Fig. 18: The junction of Grand Canal and Tianjin River..© *The Grand Canal, World Heritage nomination dossier.*

09. Chinese Taipei

Regional overview: Promotion of water heritage in the region of Taiwan in the last decades

Fig. 1: Shigang Dam which was built from 1974 to 1977 for flood control and irrigation purposes. (Dajia River Catchment Water Works). © *Sinite Yu and Zhao-Zong Wu*
Fig. 2: The inverted siphons of Baileng Canal, constructed in 1927, transported water from Dajia River through mountains and valleys and to the farm terraces (Taichung Unified Hydro System).
Fig. 3: Wushantou Reservoir and the headrace channel of Chianan Irrigation system built in the 1920s to promote the agriculture of Yunlin, Chiayi, and Tainan area (Yunlin-Chiayi-Tainan Delta Area).
Fig. 4: The outcomes of water heritage researches from the region of Taiwan. (2010-2020).
Fig. 5: Exhibition of Float or Sink: Water Culture at National Taiwan History Museum in 2019.
Fig. 6: The book of 'The archive stories during Shihmen Reservoir construction period'.
Fig. 7: The book of 'Learning Water Heritage from Shihmen Reservoir'.
Fig. 8: Water Heritage Awareness Shield in Shihmen Reservoir.

Case study 1: Babao Canal

Fig. 1: Babao Canal in the Changhua Plain. © *Ya-wen Ku.*
Fig. 2: Using 'Tsiȯh-Kô' for construction of the Babao canal headwork (about 1960s). *Source: Online Digital Collections of Old Manuscripts and Photos in Ershuei Township.*
Fig. 3: The 'Tsiȯh-Kô'were placed on the riverbed (red circles) to form several dams. © *Ya-wen Ku (2000). The Interaction between Human and Nature – a Case Study of Babao Canal. MA. National Taiwan University.*
Fig. 4: Intake of the Babao Irrigation Canal (built in 1932). © *National Cultural Heritage Database Management System.*
Fig. 5: Running Water Festival in 2018. © *Official website of the Running Water Festival.*

Case study 2: Sustainable wisdom in water irrigation engineering: Erfeng Irrigation Canal System of interflow water in Pingtung

Fig. 1: The location and layout of EICS.
Fig. 2: The construction of the underground weir in EICS. © *Cheh-Shyh Ting, 2017.*
Fig. 3: The inside of the underground weir in EICS. © *Cheh-Shyh Ting, 2017.*
Fig. 4: Lateral overflow weir, EICS. © *Szu-Ling Lin, 2020.*
Fig. 5: Main ditch of EICS. © *Szu-Ling Lin, 2020.*

10. Vietnam

Case study 1: Mu Cang Chai Rice Terraces and its water management

Fig. 1: Ripe rice terrace in Mu Cang Chai in 2020 © *Ho Ngoc Son.*
Fig. 2: Green rice terrace in Mu Cang Chai, 2020 © *Ho Ngoc Son.*
Fig. 3: Rice terrace hill developed for tourism in Mu Cang Chai, 2020 © *Ho Ngoc Son.*
Fig. 4: Rice terrace and flower circle for tourism in Mu Cang Chai, 2020 © *Ho Ngoc Son.*

Case study 2: The Red River Dikes in Northern Vietnam

Fig. 1: The Red River dikes as observed in the 1920s. Red lines represent dikes. © *J. Gauthier, Travaux*

de Défense Contre Les Inondations: Digues du Tonkin (Hanoi: Imprimerie d'Extrême-Orient, 1930).
Fig. 2 : An excerpt on the construction of the cauldron handle dikes in 1248. *Source: Lê Văn Hưu, Phan Phu Tiên, Ngô Sĩ Liên, et al., Đại Việt sử ký toàn thư 大越史記全書 [The complete book of the historical records of Đại Việt], Paris.SA.PD.2310, Bản kỷ 5, pp. 15b–16a.*
Fig. 3: 'làng tôi@ đê sông Hồng' [A village on the Red River dikes] © *Nguyen Vu Hung, 2012 Flickr user / photographer (https://www.flickr.com/people/vuhung).*

Case study 3: Water culture heritage in the Vietnamese Mekong River Delta

Fig. 1: Maps of the Mekong Basin and the Vietnamese Mekong River Basin.
Fig. 2: Water jars are put outdoors for any pedestrian who needs water to drink as a culture of sharing clean water, 2006 © *Le Anh Tuan.*
Fig. 3: The poor can catch fish freely anywhere in the VMD flood seasons, 2011 © *Le Anh Tuan.*

11. Cambodia

Regional overview: The outstanding legacy of water management from the Angkor Civilisation Period

Fig. 1: Rural landscape near Sean Reap in the present time – Cambodia. © *Michel Cotte.*
Fig. 2: The natural flooded regions and current traditional hydraulic technics in South-Eastern Asia, after Spencer J. E. and Taillard Christian, *Études rurales*, n°53-56, Paris, EHESS, 1974, p. 76.
Fig. 3: Srah Smach, ancient pond inside protection zone 1 of Sambor Prei Kuk site. © *Nomination file - Temple Zone of Sambor Prei Kuk, Archaeological Site of Ancient Ishanapura.*
Fig. 4: The first 'hydraulic city' of Angkor and its hydraulic connection with Hariharâlaya, after Groslier B. P., *Bulletin de l'Ecole française d'Extrême-Orient*, 1979, p. 198.
Fig. 5: Aerial view of the Western *Baray* with its rectangular dikes and water ring canal; it still serves as a reservoir; in the centre, the Western Mebon Temple; at the east, the Baphuong Temple is involved inside the 'Royal City' complex (Angkor Thom) constructed later. © *Google maps, 2020.*
Fig. 6: An Angkor Vat monumental access way and its square water ring in 2013. © *Michel Cotte.*
Fig. 7: The Angkor Thom moat from the square water ring at one of the radial access gates of the royal city, in 2013. © *Michel Cotte.*
Fig. 8: The Jayatataka *Baray* and the Neak Pean Temple in 2013. © *Michel Cotte.*
Fig. 9: Phra Phutthos, a Khmer bridge from the thirteenth century with corbel stone arches. © *Licence Structurae, ID 12993, JHM Cohen.*
Fig. 10: A typical smaller temple in the Angkor region with its square water ring as reservoir and remains of stone slopes of its ancient, constructed banks, 2013. © *Michel Cotte.*
Fig. 11: The Kor Ker urban restitution after recent archaeological survey, after Evans D. *Bulletin de l'Ecole française d'Extrême-Orient*, 2010, p. 141.
Fig. 12: Aerial view of Preah Khan Kompong Svay; its temple ensemble, city and hydraulic system of *baray* and square moat ring. © *Google maps, 2020.*
Fig. 13: The amazing action of nature regaining its right at Angkor Park, 2013. © *Michel Cotte.*

12. Laos

Case study: Site and landscape of Vat Phou, Lao People's Democratic Republic

Fig. 1: Vat Phou ensemble, Champasak Plain and Mekong River © *Google maps 2020.*
Fig. 2: Aerial view shows the excellent conservation of the structural design of Vat Phou complex and its implementation at the foothill of Phou Kao Mountain. © *Google maps 2020.*
Fig. 3: Restitution of the different Vat Phou *barays* (artificial surface water reservoirs) implementation related to the two successive structural axes of the site, after Jacques Dumarçay, 'Notes d'architecture khmère', in: Bulletin de l'Ecole française d'Extrême-Orient, tome 79 N°1, 1992, p. 148.

Fig. 4: The main Vat Phou axial view from the water spring sanctuary to the ritual valley with lateral temples and palaces up to the final *baray* (large surface water reservoir) and its monumental gate. © *UNESCO, Richard Engelhardt.*

13. Thailand

Case study 1: The Historic City of Ayutthaya, its water management heritage

Fig. 1: Location of Ayutthaya.
Fig. 2: Vingboons, Johannes (1663). Vingboons' maps named Iudea. *Source: Chumsai Na Ayutthaya, S (1986). Water: the Origin of Thai Culture. 184. Bangkok: Thaiwattanapanit Ltd.*
Fig. 3: The city moat at the north of the city today.
Fig. 4: One of the remaining bridges which is now under threat from new constructions. Traces of the canal can still be seen. *(Source: https://www.matichon.co.th/education/religious-cultural/news_1600373)*
Fig. 5: Remains of water tank located within the ruin of the Royal Palace at the Historic City of Ayutthaya. © *Ken May.*

Case study 2: Sukhothai Ancient City, heritage of landscape and water management (thirteenth-fifteenth centuries)

Fig. 1: The ancient city of Sukhothai **©** *Theerasak Thanusilp*
Fig. 2: Map of Sukhothai Ancient City © *Sukhothai Historical Park, 2010*
Fig. 3: The location of Sukhothai Ancient City, LANDSAT ETM image © GISTDA, 2013.
Fig. 4: Table of Sukhothai inscriptions and landscape interpretation
Fig. 5: The distribution of Sukhothai Irrigation System (ancient soil dikes) © *Sukhothai Historical Park, 2017.*
Fig. 6: Square-shaped brick well within the Sukhothai city moat © *Theerasak Thanusilp*
Fig. 7: Round laterite well within the Sukhothai city moat © *Theerasak Thanusilp*

14. Philippines

Case study: The Rice Terraces of the Philippines Cordilleras

Fig. 1: Map of the rice terraces. © *P.-F. Toulze / Open Street Map.*
Fig. 2: Banaue Rice Terrace.
Fig. 3: Pond-field terrace composition. **©** *The Rice Terraces of the Philippine Cordilleras' nomination file.*
Fig. 4: Hike through the rice terraces of Banaue, from the viewpoint back to town © *Caitriana Nicholson.*

Conclusion

The 'Bull God', an ancient deity symbolising the power of the waters on an island in China's Grand Canal near Yangzhou / *Le "Dieu Taureau", une ancienne divinité qui symbolise la puissance des eaux dans une île du Grand Canal de Chine, près de Yangzhou © Michel Cotte – ICOMOS, 2015.*

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