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カンボジアの文化復興(33)

——アンコール遺跡および伝統文化復興の研究・調査

RENAISSANCE CULTURELLE DU CAMBODGE (33)

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SPECIAL ISSUE

The Second International Symposium on the Hydraulic City

THE HYDRAULIC CITY OF THE ANGKOR EMPIRE
AND CONSTRUCTION OF ANGKOR WAT

上智大学アジア人材養成研究センター

Sophia Asia Center for Research and Human Development, Tokyo

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Yoshiaki Ishizawa
Director, Sophia Asia Center for Research and Human Development, Sophia University

In 1979, an article by B. P. Groslier was published in the bulletin of the École française d'Extrême-Orient (BEFEO). It was an important article that endorsed the "economic activities" of the highly affluent Angkor Empire, and it has since been the topic of much debate due to the reactions it evoked. If we were to present the economic setting of the period around 1113 when Suryavarman II occupied the throne, we arrive at a hypothesis of "Reservoirs, at that time (Barays)→ Double cropping→ Securing food supplies→ Population increase→ Site determination→ and Securing workers."

The alluvial fan that constitutes the main stage of the empire slopes from the north-northeast to the south-southwest, descending about one meter after about a kilometer, and fields were cultivated below. This was the origin of the intensive agriculture of the Angkor Empire. A reservoir (Baray) was constructed at a high place on the upper part of the alluvial fan by means of embankment work, water from rains and rivers was drawn into it, small grooves made within and outside the Baray served as secondary channels, and water was supplied to paddy fields through a waterway from the outlet. Erecting the grand temple of Angkor Wat took the king 37 years, despite the fact that in some places the construction is incomplete. The base has dimensions of 187 meters by 215 meters, and the five central spiers are 65 meters high (equivalent to a modern nine-story building). Furthermore, the moat has a width of 200 meters and a circumference of 5.5 kilometers, it is surrounded by 18 tiers of paving stone walls and holds approximately 5 million cubic meters of water. It was a major undertaking, and the water conservancy work in the construction was a success.

Basing ourselves on the survey report of B.P. Grolier and utilizing the 1:5000 topographic map data of the JICA, we seek to confirm the background of Groslier's theory of the Angkor Hydraulic City. This is the second international symposium on the Hydraulic City, as the first was held in the year 2000. Following the theory of historical material limitation of inscriptions pointed out by G. Cœdès in 1965 and relying on the results of the in-depth scientific research conducted by NASA and the École française d'Extrême-Orient, we shall reflect here on the national energy and wisdom of the Khmer people that enabled them to erect those massive stone temples, via the "Theory of the Hydraulic City."

開会挨拶

佐久間勤（上智学院理事長／イエズス会高等教育担当理事）

ご紹介いただきました上智学院理事長の佐久間勤でございます。本日は上智大学アジア人材養成研究センター創立25周年を記念するソフィアシンポジウムが開催されますことに心からお喜び申し上げます。

本センターはカンボジアにおいて長年にわたり「ソフィア・ミッション」としてアンコールワット遺跡修復を推進し、また修復や考古学の専門家を育成し、世界的にも注目される成果を積み重ねて来ました。そこで中心的な役割を担い、ソフィア・ミッションを牽引してこられましたのが、石澤良昭所長です。皆様ご存じかと思いますが、石澤先生がアンコール・ワットと運命的な出会いをし、生涯をその研究と修復事業にささげることになった契機は、1960年に上智大学フランス語学科３年生としてカンボジアを訪れたことにありました。その時、アンコール・ワットの「謎」を解明したい、との思いに駆られた先生は、カンボジア文化芸術省アンコール遺跡保存局の顧問でカンボジア生まれのベルナール・グロリエ先生のもとで臨時研究員となりました。グロリエ先生から「碑文ばかり読んでいても歴史はわからない。遺跡そのものに触って体で感じてみなさい」との助言を受けて、カンボジア人の保存官養成のための「保存修復研修会」に飛び入りで参加しました。その時に石澤先生はこう感じたそうです。「カンボジア人は実に手先が器用で、遺跡の石材を動かす作業など天分的な感覚を持っている」と。この時の体験が “By the Cambodians, for the Cambodians”、すなわち「カンボジア人による遺跡の保存修復と研究」という、石澤先生が掲げる国際協力の哲学を生む出発点となり、また、先生自らがカンボジア人保存官養成に携わることへとつながったと伺っております。まさに、石澤先生が受けられたグロリエ先生の薫陶が豊かな実を結んだのでした。

さて、本日のこの国際的なシンポジウムのために、海外からお越しいただいた３人の講師のかたがたに感謝申しあげます。シドニー大学のDr. ロランド・フレッチャー先生、カンボジア王国政府アプサラ機構のハン・ペウ総裁、シェムリアップに在るフランス極東学院のDr. ドミニク・スーティフ先生のお三方でらっしゃいます。皆様にはソフィア・ミッションの遂行のため、また研究所の活動のため大きなご支援をいただいております。先生方ありがとうございます。そして、シンポジウムの総合司会の労をとっていただくのは、早稲田大学名誉教授の坪井善明先生です。どうぞよろしくお願いいたします。

本日のシンポジウムが充実したものとなり、アンコール・ワットを中心に人々の交流がいっそう盛んになる重要なきっかけとなりますように、心からお祈り申し上げます。ご静聴ありがとうございました。

Opening Address

Tsutomu Sakuma
Chancellor, Sophia School Corporation,
Trustee for Jesuit Higher Education

I who have just been introduced am Tsutomu Sakuma, Chairman of the Board of Trustees of the Sophia School Corporation. I hereby convey my sincere greetings on the opening of this Sophia Symposium, commemorating the 25^{th} anniversary of the foundation of the Sophia Asia Center for Research and Human Development, of Sophia University.

As part of the Sophia Mission in Cambodia, this Center has for several years promoted the restoration of the Angkor Wat ruins, it has undertaken the training of specialists in restoration and archeology, and the success it has garnered has attracted worldwide attention. A person who played a vital role in leading the Sophia Mission is the director, Dr. Yoshiaki Ishizawa. As I am sure many of you are aware, Professor Ishizawa had a key encounter with Angkor Wat in 1960, when he visited Cambodia as a third-year student of the department of French Language Studies of Sophia University, and he was moved to devote his life to the research and restoration of the monument. At that time, urged on by a desire to solve the “mystery” of Angkor Wat, he became an interim researcher under the Cambodian-born Dr. Bernard Groslier, an advisor to the Angkor Monuments Conservation Department of the Ministry of Culture and Arts, of the Kingdom of Cambodia. Professor Groslier affirmed, “you will not understand history just by reading inscriptions. You need to touch the ruins and feel them with your body.” On getting that advice he leaped in and took part in a “Workshop on Conservation and Restoration,” for the training of Cambodian conservation officers. The feeling that Professor Ishizawa had at that time may be expressed as follows. “Cambodians are really skilled with their hands, and they have a natural sensitivity for tasks such as moving stones from ruins.” This experience turned out into becoming the commencing point for Professor Ishizawa’s philosophy of international cooperation, namely, “the conservation, restoration, and research on monuments should be done by the Cambodians for the Cambodians.” Also, I was told that he personally became involved in the training of Cambodian conservation officers. Indeed, the tutoring Dr. Ishizawa received from Dr. Groslier, was something that most certainly bore fruit.

Finally, I express my appreciation to the three speakers who have arrived from abroad for today’s international symposium. We have among us Dr. Roland Fletcher of the University of Sydney, His Excellency Hang Peou, Managing Director of the APSARA Authority of the Royal Government of Cambodia, and Dr. Dominique Soutif, of the French Far East Institute in Siem Reap. We express our gratitude to all of you for your assistance in enabling us to carry out the Sophia Mission, as well as the activities of the Institute. Professors, my sincere thanks to all of you, and also to Dr. Yoshiharu Tsuboi, Professor Emeritus of Waseda University, who will serve as the general moderator for the symposium. Thank you all very much once again.

It is my earnest hope that today's symposium turns out into becoming a fruitful venture, and a significant catalyst for the further enhancement of the exchange of people, around Angkor Wat. Thank you very much for your kind attention.

問題提起（1）

「グロリエ水利都市論と上智大学アンコール国際調査団」

坪井善明（早稲田大学名誉教授）

はじめに：

ただ今、ご紹介頂いた坪井善明です。私はベトナム政治が専門の研究者ですが、石澤良昭教授が率いる上智大学アンコール国際調査団の副団長を長年務めさせて頂いたのが理由で、本日この大役をおおせつかっています。まず、私と石澤教授との関係をご説明します。

話は48年前に遡ります。私が大学院博士課程1年の時のことです。ベトナム政治を専攻して研究者になることを志していました。指導教授は中国外交史が専門の坂野正高（ばんの　まさたか）教授でした。坂野教授から、「私は中国が専門でベトナムは門外漢だ。ベトナム研究の泰斗山本達郎（やまもと　たつお）教授を良く知っているので、山本教授の所に伺って教えを受けなさい」という指示が出ました。そこで、山本教授のもとを訪ねると、山本教授は「現在ベトナムは戦争中でとても勉学や研究をする環境ではない。ベトナムを理解するためには宗主国であったフランスに留学して、しっかりベトナムの歴史と欧米の研究方法論を学ぶことが大切だ、最近フランス留学から帰国した石澤良昭教授がフランスのインドシナ研究者の最新情報をご存じなので、石澤教授にどこの研究機関のどの教授の下で指導を受けるのが最善なのかを伺いなさい」という指示を受けました。そこで、石澤教授にお目にかかりました。石澤教授からは、「フランス社会科学院のジョルジュ・コンドミナス教授が最適だと思う。フランス人の父親とベトナム人の母親を持つベトナム民族学の泰斗で、温かい人格で世界中から留学生を受け入れてくれる素晴らしい研究者だ。ぜひ、コンドミナス教授のところで勉強して欲しい。」というアドバイスを受けました。

石澤教授のご指示を受け、コンドミナス教授に受け入れて欲しい旨の手紙を差し上げたところ、快諾のご返事を頂きました。2年後、フランス政府給費留学生として渡仏して、コンドミナス教授の指導を受けることができました。コンドミナス教授の厳しい指導を受けて、何とか博士論文を仕上げて、一人前のベトナム研究者として職を得ることができました。

その後も、山本教授の兄弟子・弟弟子の関係が続き、石澤教授から色々ご指導を受けていました。石澤教授が上智大学アジア研究所に移籍され、私は北海道大学に勤務していた時に、「この度、アンコール国際調査団を結成して本格的にアンコール寺院の調査を開始することになった。カンボジアとベトナムは隣国で強い歴史的な関係もある。ベトナム研究を続ける上でもカンボジアを知ることは意味のあることだと思うので、調査団に是非参加して欲しい」というお誘いを受けました。そこで、社会調査を担当することになり、調査団に参加して、現地調査にご一緒しました。幸いフランス語ができたので、カンボジアの知識人もフランス語に堪能な人が多く、コミュニケーションを直接取ることができました。また、フランス極東学院（L’École Française d’Extrême-Orient, EFEO）のアンコール事務所に勤務する研究者と情報交換をして、

様々な分野で協力関係を築くことができました。2003 年、EFEO と上智大学の間で正式な協力協定を締結しました。この協定により、カンボジアのアンコール遺跡の保存・修復を日仏協力で行うことが確認されたのです。

（1）EFEO の歴史

フランスは、1889 年現在のベトナム・カンボジア・ラオスの地域をフランス領インドシナとして植民地化した。同年サイゴンに研究機関としてインドシナ考古学協会を設立した。1900 年、インドシナ考古学協会をフランス極東学院（EFEO）に再編した。そして 1901 年にインドシナ総督府があるハノイに移転したのである。当初、EFEO は仏領インドシナ地域の歴史・文化・経済・社会などを調査して植民地経営に役立てる知識を提供する機関として考えられていたが、その後インドから中国・日本までのアジア全域の歴史研究なども射程に入れて、多くの優秀な研究者を雇用して世界一を目指す研究機関として構想され充実されたのである。というのも当時、世界はフランスとイギリスの二列強が植民地競争に明け暮れていて、アフリカだけでなくアジアでも激しい勢力争いが続いていた。それは単に地理的な領土の拡大だけでなく、学術の面でも覇権を争っていたからである。

1907 年、タイから旧アンコール王朝領の西北カンボジア 3 州が返還された。そこで、EFEO は 1908 年アンコール保存局を現地に設立して、本格的なアンコール遺跡の発掘が開始された。というのも、カンボジアは 1431 年にアンコール朝がタイのアユタヤ朝によって滅亡されて以降、タイとベトナムの両国から攻められていて、領土の大半は占領されていた。アンコール王朝の遺跡は森林に覆われていて、その存在はカンボジアの現地人には知られていたが、何世紀もその存在は外部に知られていなかったのである。1860 年 1 月にフランス人博物学者・冒険家のアンリー・ムーオ（Henri Mouhot,1826-1861）が 3 週間にわたりアンコール遺跡を調査した。その結果を死後に出版したことで、アンコール遺跡が外部世界に詳細に知られるようになったのである。400 キロ平方に及ぶアンコール王朝（802 － 1431）の 6 世紀以上に及ぶ統治の遺跡群の全容は、EFEO の発掘調査、保存修復事業及び精力的な現地調査や考古学的・社会科学的研究を中心とした通算 100 年以上の調査研究によってしか、解明されることはなかったのである。

アンコール遺跡を解明する有力な手掛かりに石碑がある。硬い石に刻まれた碑文は、何世紀にわたる風雨に堪え、現存している。その旧カンボジア（クメール）語で刻まれた碑刻文を最初に解読することに成功したのは 1879 年とされているが。この解読作業は続けられて数多くの新知見がもたらされた。EFEO は開設の翌年から研究論文・調査報告を発表する出版物として「フランス極東学院紀要」（Bulletin de l'École Française d'Extrême-Orient, EFEO）を刊行した。その BEFEO の第 2 号（1902）に院長で考古学者のルイ・フィノ（Louis Finot,1864-1935 ）の手により「碑文解読研究ノート」が発表され、連載された。しかし、EFEO の碑文研究を飛躍的に発展させたのが、天才的な語学学者のジョルジュ・セデス（George Cœdès,1886-1969）が 1930 年代にそれまで未解読だった碑刻文の読解に成功したことであった、セデスは 1000 以上の碑刻文を解読し、遺跡は、何時、誰が、何のために建設されたのかという謎の全容の枠組みを判明させたのである。ここで、「全容の枠組み」というのは、遺跡が、何時（when）, どこで（where）, 誰によって（who）, どんな目的で（what）建設されたのかは解明したが、どのようにして（how）

は未解明のままであった。セデス自身、碑文に基づく研究には限界があるのを自覚していた。1965年、セデスの最後となる講演で「クメール研究の将来」という題目で概要を以下のように問題提起をしている。「碑文研究という性向からどうしても王朝史、美術、宗教などの分野に偏りが見られ、当時の技術・習俗、諸信仰、経済構造や社会構造などはほとんど未解明のまま残されている。社会科学の方法論を身に着けた若い研究者たちが新しい方法論を用いて経済・社会の調査研究に取り組んでくれるなら、クメール文明のこうした諸相に関する事例を解明する研究となるであろう」と主張した。

このセデスの問題提起を真摯に受け止めたのが、ベルナール・フィリップ・グロリエ（Bernard Philippe Groslier,1926 − 86）であった。グロリエは建築家で美術教師の父親ジョルジュ・グロリエの3男としてカンボジアの首都プノンペンで生まれた。父親のジョルジュはカンボジア美術大学や国立博物館の創立者として歴史にその名を刻んでいる。13歳までカンボジアで育つが、教育のために帰国する。母親と共に戻りフランス中部のクレルマン・フェランで中等教育を受け、その後パリに上京。ソルボンヌ大学で歴史学、ルーブル校で美術史、社会科学高等院で民族学、東洋語学校でクメール語を習得。更に、考古学と民族学を現地研修した後に、1950年フランス国立科学研究センター（CNRS）の研修員としてカンボジアに戻った。そして1951年にEFEOのメンバーとなる。その後、カンボジアの独立などで混乱したカンボジアを離れ、CNRSの正式な研究メンバーとしてマレーシア、エジプト、インドなどで考古学的発掘や民族学調査などに従事した。1958年にカンボジアに戻り、EFEOに再度参画する。1959年に考古学研究部長として本格的にアンコール・ワットの環濠の発掘調査など様々なアンコール遺跡群の寺院の発掘調査に現場で辣腕を振るう。ベトナム戦争がカンボジアに拡大して混乱を極める1973年まで現場に踏みとどまる。そして、その現場で収集したアンコール遺跡群の調査研究の集大成として1979年に「アンコールの水利都市、開発か乱開発か」(La Cité Hydraulique Angkorienne, exploitation ou surexploitation) をBEFEOに発表するのである。

この論文の中で、グロリエは「水利都市」という概念を体系的に発表した。20年に及ぶ数多くの寺院・環濠・貯水池・灌漑施設などの考古学的発掘と史料調査に基づき、セデスが提起したアンコール帝国がどのように生成・発展・消滅したのか（how）という社会経済的未解明の問題に全面的に答えようとしたものだった。「水利都市」とは、一文で言えば、「100万人以上の人口を養うだけの稲作を実現するために、水を制御・管理することができた都市だった」ということである。アンコール王朝は紀元802年から1431年まで6世紀以上の統治期間を誇る東南アジアでは最長の王朝である。日本で言えば、平安・鎌倉時代にあたる。その時代に合理的な計算に基づき、大規模な貯水池と灌漑施設を設計・建設・管理・運用したことは驚異的である。それでは、「水利都市」の詳細を、日本人にも分かり易いように筆者の解説をつけながら紹介する。

アンコール寺院群があるシエムリアップ地方は、乾季と雨季がはっきり分かれた気候の地域である。雨季には雨が激しく降り、大小様々な川が出現する。時には洪水も起こる。乾季は4−5か月続き、まったく雨が降らない日が続く。田畑だけではなく、小さな川は干上がることもある。また、この地方は、小さな丘や山が点在している地形であり、こう配がある。平地には窪みもあり、水が溜まって耕作に向かない土地も多い。土壌も決して豊かなものではない。従って、乾季には水を如何に定期的・継続的に流して稲作を可能にさせるかが問題であり、雨季に

は如何に上手に排水を行うかが課題となる。

これらの気候・地形を考慮に入れて、アンコール王朝の設計者は、大規模な貯水池（バライ）を築くことにした。それも、土地を掘るのではなく、こう配地の中間点の少し上の方に石と砂と粘土と植物繊維などで水漏れしない強固で巨大な土壁を作り，上から流れてくる水を堰き止めて貯水池としたのである。この土壁の上は人や牛が通る道路として使用される箇所もあった。そばを流れる河川の水路を変更して、川の水も貯水池に導入する。そして、土塀の下部に等間隔に穴を開け、排水路とする。この排水路には板製の開閉が自在にできる排水装置を設置した。その排水路に接続する形で灌漑用の水路を格子状に作り、傾斜に沿って水が横へも縦へも流れるように工夫する。その水を稲作用に造成された田んぼ（稲田）に誘導する。稲田に流入した水も流れを作り、一杯になったら勾配を利用して下にある稲田に水を誘導する。このようにして、傾斜地に造成した稲田に効率的にもれなく水を配分するシステムを作ったのである。

アンコール王朝の諸王は、適地を探し次々に貯水池を造成して灌漑用水路を整備し、稲田を増大させてコメの増収をはかっていった。このコメの増収が、より多くの人口を養うことを可能にさせたのである。この経済的基礎に基づき、毎日数百人・数千人を動員して何十年にも及ぶ大規模な石造建築であるアンコール・ワットやアンコール・トムを始めとする寺院の建造を可能にさせた。寺院建設に従事する作業員は、カンボジア人だけでなく、戦争捕虜としてアンコールに連れてこられて強制労働を強いられたチャム人・タイ人。ラオス人など近隣諸国の戦争奴隷も多数存在したと言われる。また、食事を与えられることを聞きつけた近隣に住む山岳少数民族の人々も自発的に作業員になったとされている。

6 世紀以上続いたアンコール王朝も終焉を迎える。それはマクロ的に言うと、中小河川を利用した小舟による交易から、大帆船が出現して海に大型船で交易を行うことが主流になったという大きな技術革新による交易ルートの変更があったことを指摘できる。この交易ルートの変更に伴い、世界的な交易では外洋に面する港を持つ国々が繁栄し始め、内陸部に位置して中小河川を利用して交易するアンコール朝の重要性が減少していったのである。この外因だけが、滅亡の主因ではない。二つの内因が考えられる。一つ目は寺院建設に大量の木材が使用され、それによる森林伐採が挙げられる。森林伐採は、土壌の劣化を招く。森林に含まれるミネラル質が失われ、土壌の質が低下するのである。さらに、森林が持つ保水力が減少して、結果として河川や地下水の水量が減少することになる。少し詳しく説明しよう。雨季には森の樹木が水分を保持し、枯れ葉などが堆積した土壌も水を貯えて、徐々に配水する。森林伐採が進むと、雨水はそのまま流れてしまう。また、乾季には伐採された地面に太陽が直接当たり、土も乾き切ってしまう。それ故、全体として河川・地下水・貯水池に入ってくる水量は減少してしまうのである。二つ目は、貯水池や用水路に泥が堆積してしまうことである。シエムリアップ地域では粘土を含む砂の土壌が大半を占め、泥土になるのは時間がかかる。然し、何十年の単位では徐々に底に沈殿していく。それ故、貯水地の水量が減少していくことになった。記録では、浚渫を行った形跡がない。貯水池の水量が減少すると、灌漑用水路に流れる水量も減少するとともに、水流の速度も減少する。そのため、用水路にも泥が堆積してしまう。一種の灌漑用水路の動脈硬化現象が生じることになる。このため、稲田の水量も減少し、水流の速度も減少して下にある稲田への水の流れも減り、遅くなる。このような負の連鎖が次々と起こり、コメの収量の減少

に繋がるのである。

だが、水流の減速は、別種類の負の作用を起こした。水がアチコチに滞留して、蚊が多量発生する。これにより、マラリアに感染する人びとも大量に発生したのである。コメの減収により食糧事情が悪化した状況下でマラリアに罹ると、抵抗力を失った作業員などが働けなくなることもあったことは容易に想像できる。すなわち、「水利都市」が水の管理ができなくなり、貯水池の水の減少、用水路の動脈硬化などでコメが減収して、多くの人口を維持できなくなった。更に滞留した水に発生した大量の蚊が媒介するマラリア等の病気が蔓延して作業員や兵士の膨大な労働力の減少に繋がり、帝国自体の衰退を生じさせたのである。以上がグロリエがアンコール帝国の生成・発展・消滅を社会経済的に説明した「水利都市」の骨子である。副題の「開発か乱開発か」というのは、水を上手に利用して大帝国の発展に貢献した「開発」だったが、以降あまりにも規模を拡大して、かえって森林伐採、貯水池の泥の堆積、灌漑用水路の「動脈硬化」、滞水による大量の蚊の発生に起因するマラリア等の病気の蔓延などを惹起して、帝国の滅亡の原因の一つになったのは「乱開発」に結果ではなかったかという問いかけだと、筆者は理解している。

筆者のフランスの指導教授でグロリエを個人的にも良く知っていたジョルジュ・コンドミナス教授はグロリエの業績を以下のように賞賛している。「グロリエの「水利都市論」はフランスの社会学者のマルセル・モースの「全社会現象」の概念に影響されたり、アナール学派の創設者の一人のフェルナン・ブローデルの「長期理論」刺激されたりして、グロリエが生み出した全く新しい文化人類学的理論に立脚しているのである。その基礎に、彼が若いころから勉強した考古学・美術史・歴史学・民族学・建築学などの学問的素地があり、何よりもアンコール遺跡の数多くの現場での考古学的発掘調査の経験があったからである。それに加えて、カンボジア国立博物館の創立者を父親に持ち、自分自身もカンボジアで生まれ、幼少からカンボジアになじみ、深い愛があったからこそ、この「水利都市論」という新しい学問統合・新理論が誕生したのである。」

(2) 上智大学アンコール国際調査団

アンコール王朝以降、カンボジアは苦難の歴史を歩んでいる。隣国のタイのアユタヤ王朝とベトナムの黎朝・阮朝から領地を蚕食され、アンコール王朝全盛期の版図の半分ほどまでに領土は減少させられたのである。1863 年、当時のカンボジア王ノロドムはタイとベトナムの二重属国状態を逃げ出すために、自発的にフランスの保護国化を求めた。その後、現在のベトナムとラオスの版図を合わせた形で「フランス領インドシナ連邦」が発足するとその一部となった。1955 年、ノルドム・シアヌークの尽力によってようやく独立を獲得して、「カンボジア王国」を建国する。しかし、東西冷戦最中の「熱戦」としてベトナム戦争が闘われていて、カンボジアのその渦中に巻き込まれる。1970 年、親米派のロン・ノル将軍がクーデターを起こし、シアヌーク国王を追放して「クメール共和国」を樹立。しかし、ベトナム戦争でホ・チ・ミン主席が率いた「北ベトナム」が勝利すると、カンボジアでは共産勢力で中国の毛沢東思想に強い影響を受けたクメール・ルージュが政権を奪取する。ポル・ポトが率いる民主カンプチアが 1976 年に成立する。そして、極端な原始共産制を実施し、知識人や公務員など 200 万以上の人々が殺戮

などの不審死とされ、500万人以上のカンボジア人が国外に亡命したとされている。国民が虐殺される中、親ベトナム派のヘン・サムリンがベトナム軍の支援を受けてクメール・ルージュから政権を奪取して、1979年カンプチア人民共和国を樹立した。この親越政権に反対する3つの異なった政治勢力（シアヌーク（王党派)、ソン・サン（自由主義)、ポル・ポト（共産主義)）が協力して「民主3派」を結成してヘン・サムリン政権に対峙することになり、事実上内戦が続いた。1986年にベトナム軍が全面撤退をして、局面が動く。1990年、日本政府はイニシアティヴを発揮して、カンボジア和平に関する東京会議を開催して、関係者を招待した。そして、国連も動き、国際連合カンボジア暫定統治機構（UNTAC）という統治機関がカンボジアを一時的に統治して、総選挙を行うとした。このUNTACの事務総長に日本人の明石康氏が就任した。1992年に総選挙が実施され、1993年にシアヌークを国王とする「カンボジア王国」が成立したのである。ようやく、カンボジアに平和と安定が訪れたのだ。

石澤良昭教授は、上智大学外国語学部フランス語科の卒業である。だが、1959年の3年生の夏にフランス人教師に引率されてフランス語語学研修のためにカンボジアに行く。それ以前から強い興味を抱いていたアンコール・ワットを見学して、人生を変えるほどのショックを受ける。当時フランスの植民地から解放されたばかりのカンボジアは、弱小国として知られていた。しかし、その時よりも1000年以上前に想像を絶する大伽藍の寺院を建造したことに、衝撃を受けたのである。誰が、どのような理由で、どんなやり方でこんな大伽藍を作ったのか？その謎を解いてみたいという強い誘惑に捉われたという。その後、アンコールに駐在して研究を続けるEFEOの専門家と出逢い、フランス語で質疑応答をして、フランス語を武器にカンボジア語を習得して、学問的な方法論を学習すれば、アンコール遺跡を本格的に研究する研究者になる道筋が見えたのである。だが、同時にEFEOのフランス人のカンボジア人に対する態度に違和感も持った。宗主国として80年以上植民地支配を続けてきたフランス人には、目線が高いというかカンボジア人に対する蔑視感が身についていて、「どうせ現在のカンボジア人にはアンコール遺跡の保存修復などはできっこない。宗主国であるフランスの我々フランス人が責任をもってするしかない。」という態度をあからさまに示していたからである。同じアジア人の日本人として、カンボジアを助けることができることを確信したのである。

歴史学に進路を変更し、中央大学大学院で歴史学を専攻する。この院生時代にも数度休みを利用してカンボジアを訪問して、自分の学問原点を確認した。そして、カンボジアン史に関する博士論文を仕上げて、博士号を取得する。さらに、フランスに留学してセデス門下のEFEOでアンコール王朝時代の石碑文の解読を学び、日本では数少ないカンボジア専門家になったのである。

資料が少ない日本でのカンボジア研究には限界があり、現地で資料収集を含めて研究をする必要があった。そこで、内戦が激しく行われている1980年から機会を捉えては、命がけでカンボジアに渡航を試みて、出来るだけ現地の生の情報を集めていた。この間に、カンボジア専門家・外交官で後にカンボジア大使となる今川幸雄氏などカンボジアを愛する日本人との親交を深め、遺跡保存・修復という文化教育活動が、どのような形でカンボジアの和平構築や文化復興に結び付くのか等の議論を行っていた。さらに、カンボジア文化省遺跡保存局、王立芸術大学考古学科・建築学科などとアンコール遺跡保存・修復に関する機関と日本とカンボジアとの文化協

力を具体的にどのような形で進めるかについての協議をおこなっていた。というのも、1960年代には80名近く存在していたアンコール遺跡を守るカンボジア保存官が、内戦やポル・ポトの虐殺などによって1990年時点でわずか3名しか生存していないことが判明したからでもある。

1991年、日本政府も積極的に貢献するカンボジア和平を実現する過程で、文化面での日本の協力も必要だという機運が関係者の中で盛り上がった。そこで、石澤教授を団長とする上智大学アンコール遺跡国際調査団が結成されて、本格的な現地調査を開始することが決定されたのである。筆者も最初からこの調査団に副団長として参加して現地に足を踏み入れた。1991年当時のカンボジアは、ようやく内戦が終了して平和が訪れた時期であったが、戦争の傷跡は深く大きかった。アンコール遺跡のあるシエムレアプ州の人びとの暮らしは貧しく、ほとんどシャツ一枚で暮らしていた。建物も古く、崩れた個所の修復にも手が回らない状況だった。外国人だと分かると、物乞いやわずかな果物や野菜を持つ人が「一ドルくれ。」「一ドルで買ってくれ」と群がって周囲を取り巻いた。

12世紀に建設されたバンテアイ・クデイ寺院の発掘調査・保存修復を文化省遺跡保存局から委託された。何十年と放置されていたバンデアイ・クデイ寺院はうっそうと茂る草や木々に覆われていた。まず、それらを取り除く必要があった。そして、遺跡の保存の基本三原則を実施することだった。その三原則とは①遺跡の雨水を取り除く，②樹木の芽を摘む、③黒カビを除去する、の3点である。そこで、遺産保存局のソン・コン局長などと相談して、近隣の村の住民にアルバイトの形で草刈り・木材伐採をお願いすることにした。住民にとっても近くの職場で現金収入を得る絶好の機会となるし、我々にとっても、地域の人々と交流する機会になるし、調査団が不在の時にバンテアイ・クデイ遺跡を保存する役割を伝授して実行する役目を果たしてもらうことが期待できたからである。

さらに、首都プノンペンにある王立芸術大学の考古学科と建設学科の各10名の学生にも参加を求めた。渡航費や宿泊費はもちろん調査団が支払った。戦乱に明け暮れていたカンボジアでは、首都のプノンペンからトンレサップ湖の対岸に位置するシムレアップ州にあるアンコール遺跡にまで観光に来る余裕を持つ人は存在していなかった。それ故、将来アンコール遺跡の保存修復に関連する仕事を夢見てカンボジアの最難関の大学の考古学科・建築学科に入学してきた20名の学生全員が、それまで一度もアンコール遺跡を自分の眼で見る機会はなかったのである。それらの学生を現場研修の一環として連れてくることも隠された目的であった。学生たちと話をしてみると、戦乱のために十分な授業もされていないことが判明した。そこで、試しに学生が望む講義を現地で行うことに決めた。というのも、幸いにも調査団は考古学・建築学を始めとする各分野の専門家で構成されているので、学生の要求に応える体制ができていたからである。現地での講義は好評だったので、翌年からは王立芸術大学での集中講義も調査団のミッションの一つにすることが会議で決められた。その講義のために、十分な準備をすることも検討された。

1992年、93年の8月に調査団はバンテアイ・クデイ寺院の発掘調査・保存修復を中心とする活動のために現地に滞在した。王立芸術大学の考古学科・建築学科の学生への集中講義も常態化した。そして、バンテアイ・スレイ、プレヤ・カーン。アンコール・ワット、アンコール・トム、バイオンなどのアンコール遺跡の他の寺院も見学した。また、遺跡保存局のソン・コン局長などとも協議を続けた。

その結果、調査団の活動の基本路線を信条という形で公表することとした。すなわち、「カンボジア人による、カンボジアのための、カンボジア遺跡の保存修復」をスローガンとして、その実現のために調査団は全面的に支援活動を行うこととしたのである。

日本の文部科学省とも相談して、カンボジア人学生が上智大学大学院に日本政府留学生として留学する道も開いた。現在までに 17 名（博士号取得 6 名、修士号取得 11 名）のカンボジア留学生が上智大学大学院で学び、現地の文化省や遺跡保存局などで専門家として働いている。

UNTAC が実施した総選挙の結果を受け､1993 年 9 月には新生「カンボジア王国」が発足した。カンボジア新政府は課題が山積していたが、アンコール遺跡保存修復事業に本格的な取り組む新体制を組織することを決定した。それが、略称アプサラ（カンボジア語で天女・天使）と呼ばれる「アンコール地域遺跡保存整備機構（National Authority for Protection and Management of Angkor and the Region of Siem-Reap)」である。1994 年に正式に創設され、その総裁は文化大臣も兼任する著名な建築家のヴァン・モリヴァン氏だった。

1994 年、駐カンボジア日本大使だった今川幸雄氏のご厚意で、シアヌーク国王に直接上智大学アンコール国際調査団の活動を報告する機会を与えられた。筆者も副団長の資格で、石澤団長と今川大使と共に王宮に伺い、シアヌーク国王と直接会話する栄誉を受けることができた。

1995 年、調査団はアンコール・ワット西参道の修復工事をアプサラから委嘱された。ようやくカンボジアにも平和が回復され、世界中からアンコール遺跡を見たいという希望が殺到していた。カンボジア政府も世界中からの観光客を受け入れる体制を確立し、それを経済発展の一助にしたい思惑もあった。アンコール・ワットは観光客が殺到する中核であり、その参道を強固にして観光客の安全を守ることは緊急の課題だったのである。

このアプサラの要請に応えるために、調査団は日本中の建築修復専門家・専門機関の協力を仰ぎ、「オール日本」体制で取り組む組織を作った。協賛してくれた日本大学工学部の片桐正夫教授を始めとし、東北工業大学盛合禧夫教授、奈良女子大学上野邦一教授などの研究者たちと奈良文化財研究所・東京文化財研究所などの国立研究機関との協力を受けて支援体制を組織した。1996 年に､現地での拠点作りの意味も込めて「上智大学人材養成研究センター」をシムリアップ州に一軒家を購入して開設したのである。

このセンター長は石澤良昭教授が現在まで継続して勤めている。1996 年に始まったアンコール・ワット西参道の修復工事は第一期が 1996 年から 2007 年までの 12 年間かかって修復された。西参道は長さ 200m、幅 12m だが、1960 年代にその右半分が EFEO のフランス人が指導して修復された。だが､残りの左半分はアンコール寺院建設当時のままに残されていて, 通行禁止になっている。その長さ半分の 100m を第一期工事でカンボジア人と日本人を中心とする国際チームで修復したのである。12 年間の長い歳月がかかったのは、当時と同じ工法や材質を使用して真正性（オータンティシティ、authenticity）を担保する必要があったからである。すなわち、研究と修復事業が同時並行的に行われる必要があったので時間がかかったのである。残りの 100m を修復する第二期工事は 2016 年から開始された。残念ながら、新型コロナ感染症の世界的な流行のために、当初予定されていた工期が延長せざるを得ないのが現状である。

アジア人材養成センターは以下の 7 つのプロジェクトを定めて実施している。

1）人材養成（考古発掘、建築系保存科学、地域のリーダー等）
2）アンコール・ワット西参道の修復工事（建築技術の解明）
3）アンコール王朝の考古・建築調査による歴史解明研究
4）文化遺産の修復を通じたアセアンの南・南協力の推進
5）文化遺産の啓蒙教育（小中学生の遺跡修学旅行、住民啓発講座）と無形文化財の保存活動
6）環境保全と ISO14001 の推進
7）日本・カンボジアの次世代リーダーの養成と交流

1997 年、日本国際協力事業団（JICA）はカンボジアの農業開発の技術協力の一環として、アンコール地域を人工衛星による写真で撮影して、5000 分の一の地形図を作成することに成功した。2007 年 8 月には米国航空宇宙局（National Aeronautics and Space Administration: NASA）の国際調査チームがアンコール地域に入り、解像度 1 メートル以下の画像解析機器と高解像レーダーを持ち込み、アンコール王朝時代（9 − 15 世紀）の水利施設と水路跡を現地で確認して公表した。

上智大学アジア人材養成研究センターは JICA の作成した 5000 分の一の地形図を入手して、立体模型の地形を詳細に作製することにした、NASA が作成した資料も入手して、参照史料として活用している。

これらの詳細に作製された立体地形によって、グロリエが説明していた「田超え灌漑」システムが現実に行われていたことを立証したのである。

（3）日・カンボジア協力と EFEO の学術成果の継承

カンボジアでは、様々な政権が権力を握って次々と国家を樹立したが、その国旗のデザインは、すべてアンコール・ワットが使われている。デザインは各自で異なっているが、カンボジアの「文化の象徴」「カンボジア国民の誇り・精神的支柱」としてアンコールが観念されているのは間違いない。アンコール遺跡群は、ギリシアのパンテオンやローマの円形コロシアムなどと並んで世界に比類のないトップクラスの人類の遺産の一つであることは、国籍を問わず世界の誰もが認める文化価値を持っている。

1991 年に上智大学アンコール遺跡国際調査団が初めてカンボジアを訪問した時、文化省との協議では、重要課題の一つとして「アンコール遺跡群を UNESCO の世界遺産にいかにして登録することができるか」について話し合いが行われた。筆者も同席したが、世界遺産に登録申請するためには、まず国内で法律を整備して国立公園など自国でも高い評価を与え、それに伴う予算や人員の保護管理体制を確立する必要がある。戦乱に明け暮れていたカンボジアでは、法律も保護管理体制も存在していなかった。それ故、第一に手を付けるべきは、国内法と保護管理体制の確立であった。第二の課題は、どのように申請するのかという具体的な手続きの問題であった。申請書類の書き方や申請方法などに関しても、カンボジア文化省は未体験で誰も知らなかった。文化省を知的支援するために、筆者はパリに本拠を置くユネスコ世界遺産委員会と接触した。関係者に「カンボジア政府はアンコール遺跡群の世界遺産登録身に意欲的であること。和平回復・新生カンボジア王国の誕生のシンボル的意味がアンコール遺跡群の世界遺産

登録にはあること」などを主張して、協力を求めた。ユネスコ世界遺産委員会は好意的に受け止めてくれて、申請登録の手法・手続きなどを親切に享受してくれた。その情報をパリからプノンペンに持ち帰り、早速文化省の担当官たちと協力して申請手続きを迅速に行った。1992年末、異例の速さで世界遺産委員会は条件付きではあるが、アンコール遺跡群の世界遺産登録を承認するという判断を出してくれた。条件とは、カンボジア国内でアンコール遺跡群を保護管理する機関を出来るだけ早く設立して実際に保護・管理を行うことであった。このユネスコ世界遺産委員会の条件に応じる形で、「アプサラ機構」（アンコール地域遺跡保存整備機構）である。

この世界遺産登録を通じて、カンボジア文化省やアプサラ機構と調査団との間の相互信頼関係は強固なものになった。アプサラ機構は優秀な保存官が圧倒的に不足していて、その人員の養成と確保が焦眉の急の課題であった。ヴァン・モリヴァン総裁からは「上智大学も将来のアンコール遺跡群保存官を育成して欲しい」という要請が何度も寄せられた。それに応じた形で。文科省と協議の上、日本政府国費留学生として来日して大学院で学ぶ道を開いた。大学院では保存科学・考古学・建築学などを受講して、功労して修士号そして博士号を取得した。現在までで修士号・博士号を取得したカンボジアリュ学生は17名に及び、アプサラ副総裁、文化省遺跡保存局長、国立博物館館長などの要職を占める卒業生も多数輩出している。

カンボジアに関するEFEOの業績は、石澤教授を中心に主要な著書や論文が日本語に翻訳されて出版されている。幾つかの著名な例を挙げてみよう。セデスの主著『インドシナとインドネシアのインド化した国々』(Les états hindouisés d'Indochine et d'Indonésie)（Paris, 1964）は、わずか5年後の1969年に概説書としてみすず書房から『インドシナ文明史』として出版されている。その全訳は、1989年に『東南アジア文化史』（大蔵出版）として出版された。また、グロリエの主著の一つ、『ポルトガル及びイスパニア史料による16世紀のアンコールとカンボジア』（Angkor et le Cambodge au XVI^{e} Siècle, d'après les sources Portugaises et Espagnoles）（P.U.F. 1958）は、1960年に金山好男氏の訳で東洋文庫の紀要「東洋学報」に掲載された。それは専門家の読む論文だったので、石澤教授は中島節子さんと共訳というかたちで一般読者向けに単行本『西欧が見たアンコール―水利都市の繁栄と没落―」（連合出版、1997年）である。

2003年にはEFEOと上智大学の間で学術協定が結ばれた。アンコールの現地では、上智大学はバンテアイ・クデイ寺院を、EFEOは西バライ（貯水池）を担当していた。EFEOは数名のフランス人メンバーが常駐する形で研究を進めていた。上智大学は調査団を派遣していた1991－1995年までは常駐体制を取るシステムは出来てなかった。EFEOを手本として常駐体制を構築することを模索していた。幸い、1996年に人材養成研究センターを設立して一軒家を購入して以降、数名の常駐員を置く体制がやっとできたのである。

しかし、EFEOはフランス政府の国家予算が減少して文化面での削減が大きくなり、2019年にはカンボジアのアンコール現地事務所を閉鎖することが余儀ない情勢に追い込まれた。それ故、西バライの保存修復活動からも手を引くことになったのである。従って、長年アンコール遺跡の保存修復活動に携わっている機関は上智大学だけになってしまい、より責任が大きいものとなったのである。

今回、第2回目のグロリエの水利都市論を中心とする国際シンポジュウムを開催した主催者の狙いは、EFEOが70年以上の歳月をかけて調査研究してきたアンコール遺跡群の研究成果を、

上智大学アンコール国際調査団及び人材養育研究センターはしっかり検討して継承していかなければならないことを確認するためである。

グロリエの「水利都市論」は、スケールの大きいアンコール帝国全体のシステム解明を目指すものである。現代の先端技術を駆使したJICAやNASAの宇宙からの航空写真を解析すると、グロリエの仮説を実際に確認できる側面が発見できた。今後も、EFEOの学術成果だけではなく。長年培われたアンコール遺跡の建物・貯水池・道路・環濠・橋などの保存技術・修復技術も正確に分析して後世に伝える必要がある。したがって、今後の我々の活動の指針（ガイドライン）は以下の5点に整理できる。

1）グロリエの「水利都市論」を地理的に分割して小グループに分け、先端技術の宇宙航空写真などを活用して、より詳細な立体地形図を製作して、水流や水量までも正確に測定して、グロリエの「水利都市論」の検証を細部にわたるまでに行う。

2）アンコール・ワット。西参道の第二期工事に取り組む中、第一期工事で明らかになったEFEOが用いた「アナスティローズ方式（古代ギリシヤのパンテオン円柱の再建方式)」の長所と短所を充分に検討して、その方式を適用するかどうかを決定する。添えと並行して、参道の修復技術の研究を推進する。

3）ポスト・コロナ時期に、世界から観光客がアンコールに戻ってくることを想定して、アプサラ機構と協力して、2年以上コロナ禍で保存修復管理が出来なかった遺跡寺院・環濠・参道・橋などの総点検を行う。アンコール遺跡群全体の安全マップを作成し、危険な個所には注意喚起を促すボードを設置する。

4）カンボジア人保存官養成のための日本留学制度を増強するばかりではなく、フランスを初めとする遺跡修復先進国に呼び掛けて、カンボジア人学生の留学を増やす努力をする。

5）ベトナム・タイ・ラオス・インドネシアなどのアセアン諸国で石造遺跡のある国々から専門家や研修生をアンコール遺跡の保存修復現場に招待して、現場研修を行うという「アセアン南·南協力」事業をコーディネーターとして増進する役割を果たす。

以上で私の報告を終了します。最後に一つ皆様にお願いがあります。上智大学は私立大学で、人材養成研究センターも基本的にはこの事業に共鳴して下さった方々の浄財をクラウド・ファウンドで集約したのを基金として運用されています。もちろん、日本政府の文化省・国際協力機構（JICA)・国際交流基金などの公的機関からも時折支援を受けています。しかし、アンコール遺跡は広大な規模を持つ遺跡群で、その保存・修復や研究には莫大な時間と人員が必要です。この事業は、現在まで石澤良昭教授のアンコールに対する情熱と驚くべき忍耐力が原動力となって推進されてきましたが、石澤教授も現在85歳で頑張っておられます。多分、あと15年以上、100歳を超えるまでは生涯現役でアンコール遺跡保存修復事業に奮闘し続けて下さると確信しています。

この事業を後世に残すためにも日本の若い世代の研究者・技術者・保存官が引き継ぐことが肝要です。そのためには「オール日本」が団結して、石澤教授が「後世に託しても大丈夫」と思って頂く程度の浄財と協賛人数を欠かすことができせません。今にもまして、アンコール遺跡保存修復事業に対する皆様の深いご理解と熱いご支援を心よりお願いする次第です。ご清聴、ありがとうございました。

“Groslier’s Theory of the Hydraulic City and the Sophia University Angkor International Mission”

Yoshiharu Tsuboi
Professor Emeritus, Waseda University

Introduction

I who have just been introduced am Yoshiharu Tsuboi, a researcher specializing in the politics of Vietnam. However, I have served several years as the deputy leader of the Sophia University Angkor International Research Team of Professor Yoshiaki Ishizawa, and that is the reason why I have accepted this critical role today. To begin with, let me explain my relationship with Professor Ishizawa.

The story goes back 48 years, to a time when I was in the first year of my doctoral study. My desire was to major in Vietnamese politics and become a researcher. My director Professor Masataka Banno, who was a specialist in Chinese diplomatic history, instructed me as follows, “I specialize in China and I am not familiar with Vietnam. Since I am well acquainted with Professor Tatsuo Yamamoto who specializes in Vietnam studies, please visit Professor Yamamoto and study with him.” When I subsequently met Professor Yamamoto, he said, “Currently, Vietnam is at war, and it is not a milieu for study and research. In order to understand Vietnam, it is essential to study abroad in France, the suzerain state, and acquire knowledge of the history of Vietnam as well as Western research methodologies. Since Professor Yoshiaki Ishizawa who returned recently from studies abroad in France possesses the latest information concerning French Indochina researchers, please ask Professor Ishizawa as to which research institute would suit you the best, and which professor would be the most suitable to provide you with the necessary guidance.” I thereupon met Professor Ishizawa, who gave me the following advice. “Professor Georges Condominas of the French Academy of Social Sciences would be the best choice for you. He is a great authority on Vietnamese ethnology, with a French father and a Vietnamese mother, and a splendid researcher with a warm nature who welcomes students from all over the world. By all means study with Professor Condominas.

Following the advice of Professor Ishizawa, I dispatched a letter to Professor Condominas requesting acceptance as a student and received a willing reply, two years later I was able to travel to France as an international student on a French government scholarship and receive guidance from Professor Condominas. Under the strict supervision of Professor Condominas, I managed somehow to complete my doctoral dissertation and obtained a job as a full-fledged Vietnamese researcher.

Even later, my links with Professor Yamamoto as an elder and senior endured, and I also received guidance from Professor Ishizawa in a variety of ways. When Professor Ishizawa transferred to the Institute of Asian Studies at Sophia University and I happened to work at Hokkaido University, I received the following offer from him. “On this occasion, we have decided to form an international research team for Angkor, and we have begun a full-scale survey of the Angkor temples. Cambodia and Vietnam are neighboring nations with strong historical ties, and I think that would be something significant for you. Hence I would like you to join the investigation team.” Thus, I was put in charge of a social survey, and so I joined the survey team and participated in the field survey. Fortunately, however I was able to speak French, and since many Cambodian scholars were fluent in French as well, direct interaction with them was possible. Also, I was able to exchange information with researchers working at the Angkor office of the École française d’Extrême-Orient (EFEO) and build up collaborative relationships with them in diverse fields. In 2003, a formal cooperation agreement was concluded between the EFEO and Sophia University, and via this agreement, it was settled that Japan and France would cooperate in the conservation and restoration of the Angkor ruins of Cambodia.

1. The History of the EFEO

In 1889, France had colonized the area of present-day Vietnam, Cambodia, and Laos, as French Indochina, and in the same year they established the Indochinese Archaeological Society, as a research institute in Saigon. In 1900, the Indochinese Archaeological Society was reordered into the École française d’Extrême Orient (EFEO), and in 1901 it was moved to Hanoi, where the office of the Governor-General of Indochina was situated. The EFEO was initially conceived as a body to carry out research on the history, culture, economy, society and other such features of French Indochina, and thereby provide information that would be beneficial for the colonial administration. Later however it came to be conceived and enhanced as a research institute that aimed at becoming the foremost in the world, by employing numerous outstanding researchers and including within its circle historical research on the entire region of Asia, comprising India, China, and Japan. That was an era when the world was directed by a colonial rivalry between the two great powers of France and Great Britain, and fierce power struggles persisted, not just in Africa but in Asia as well. This was due to the fact that they were competing for supremacy not merely in terms of geographical expansion, but in terms of academic supremacy as well.

In 1907, three provinces of Northwest Cambodia that were formerly under the Angkor dynasty were returned by Thailand. Accordingly, the EFEO established in 1908 the Angkor Preservation Authority, and full-scale excavation of the Angkor ruins commenced. That is to say, after the Angkor dynasty had been overthrown by the Ayutthaya dynasty in 1431, Cambodia was invaded by both Thailand and Vietnam, and most of its territory had been occupied. The ruins of the Angkor dynasty were covered by forests, and although their existence was known to the local people in Cambodia, for centuries their presence was unknown to the outside world. In January

1860, French naturalist and adventurer Henri Mouhot (1826-1861), surveyed the Angkor ruins for around three weeks. By publishing posthumously, the results of his survey, the ruins of Angkor became known to the outside world in detail. The revelation of the 400 square kilometer ruins of the Angkor dynasty (802-1431) that ruled for over six centuries, is the outcome of the excavation, conservation, and restoration projects conducted by the EFEO, as well as the forceful field surveys and archaeological and social scientific research, undertaken by them. It could only have been elucidated through investigative research, covering over a hundred years.

Stone monuments served as potent clues for the exposition of the Angkor ruins. The inscriptions carved in solid stone have resisted the elements for centuries, and they are still extant. It is said that the first successful deciphering of the inscriptions inscribed in the old Cambodian (Khmer) language, occurred in 1879. This work of deciphering continued and yielded various new discoveries. A year after its creation, the EFEO issued the Bulletin de École française d'Extrême-Orient (BEFEO), as a publication announcing its research papers and survey reports. In the second issue of BEFEO (1902), the director and archaeologist Louis Finot (1864-1935) published and serialized "Research Notes on Deciphering Inscriptions." However, a great leap forward in the study of EFEO inscriptions came in the 1930s, when the gifted linguist Georges Cœdès (1886-1969) became successful in decoding hitherto undeciphered inscriptions. Cœdès deciphered more than 1,000 inscriptions, thereby revealing the entire framework of the mystery of when, by whom, and for what purpose the ruins were constructed. Here, the term "entire framework" indicates a clarification of the issues as to when, where, by whom, and for what reason the monuments were erected, as well as the issue as to how certain points remain unexplained. Cœdès himself was aware of the limitations of research based on inscriptions. In 1965, in what was to be his final lecture titled "The Future of Khmer Studies," Cœdès insisted on the following issues. "Owing to the tendency to study epigraphs, there appears to have arisen a bias towards the study of dynastic history, art, and religion, while the technology, customs, beliefs, as well as the economic and social structures of the time, are largely unexplored. If young scholars who have acquired the methodology of the social sciences utilize these new methodologies in conducting research on the economy and society, it will be possible to elucidate cases related to these aspects of the Khmer civilization."

This problem presented by Cœdès was taken seriously by Bernard Philippe Groslier (1926-86). Groslier was born in Phnom Penh the capital of Cambodia, as the third son of the architect and art teacher Georges Groslier. His father Georges made his mark in history as founder of the Cambodian University of Fine Arts, and the National Museum of Cambodia. He was raised in Cambodia until the age of 13, and returned to his own country for his education. He returned with his mother to Clermont-Ferrand in central France for his secondary education, prior to moving to Paris. He then studied history at the Sorbonne, art history at the École du Louvre, ethnology at the School for Advanced Studies in the Social Sciences, and Khmer at the Institute of Oriental Languages and Cultures. Furthermore, after field training in archaeology and ethnology he returned to Cambodia in 1950 as a trainee at the French National Center for Scientific Research (CNRS), and in 1951 he became a member of the EFEO. Later, he left Cambodia which had fallen into a state of turmoil due to the nation's independence and other issues, and engaged in archaeological excavation and ethnological surveys in Malaysia, Egypt, India, and other places, as an official research member of the CNRS. In 1958 he returned to Cambodia and rejoined the EFEO, and in 1959 he commenced full-scale excavation of the moat of Angkor Wat, and other excavations of numerous temples in the Angkor Complex, as Director of the archaeological research department. He remained at the scene until 1973, when the Vietnam War expanded into Cambodia and the situation became extremely chaotic. In 1979, as the climax of his research on the Angkor sites that he had achieved in the field he published "The Angkorian Hydraulic City: Exploitation or Over-exploitation of the Soil?" in the BEFEO.

In this work, Groslier presented in an orderly way the concept of a "Hydraulic City." On the basis of around 20 years of archaeological excavation, and historical research conducted on numerous temples, moats, reservoirs, irrigation facilities, and so on, he sought to provide a complete answer to the unsolved socio-economic query posed by Cœdès, namely 'how' the Angkor Empire was created and developed, and how it vanished. The term "Hydraulic City" signifies in brief "a city that was able to control and manage water, in order to cultivate enough rice to feed a population of over a million." The Angkor dynasty was the longest reigning dynasty in Southeast Asia, with a reign extending over 6 centuries, from A.D. (802–1431). With reference to Japan, it would correspond to the Heian and Kamakura periods. In that era, the fact that they designed, constructed, managed, and operated large-scale reservoirs and irrigation facilities based on rational calculation, is indeed astounding. I would hereafter like to introduce the details of the "Hydraulic City'" along with the author's commentary, so that it becomes easy for the Japanese also to understand.

The Siem Reap region where the Angkor temple complex is located, has a climate that is clearly divided into dry and rainy seasons. During the rainy season the rains are torrential. Rivers of various sizes appear, and at times flooding occurs. The dry season lasts for around 4 to 5 months, and days pass by with no rain at all. Here it is not just the fields, but at times small rivers also dry up. Moreover, as this region is a terrain dotted with small hills and mountains, slopes are seen, and there are also depressions in the plains. Much of the land is unsuitable for cultivation due to the accumulation of water, and the soil is not rich either. Consequently, the problem was how to make rice cultivation possible with regular and nonstop water flow during the dry season, and how to drain the water well during the rainy season.

Taking these climates and topographies into consideration, the designers of the Angkor dynasty decided to build a large reservoir (Baray). Here too, instead of digging the land, they erected a firm and massive earthen wall utilizing stones, sand, clay, plant fiber, and other resources to prevent water leakage a little above the midpoint of the terrain, thereby damming the water flowing from above and creating a reservoir. In some places, the tops of these earthen walls were utilized as paths for people and cattle. They also diverted the waterways of nearby rivers to introduce the river water into the reservoir and drilled holes at equal intervals in the lower part of the earthen wall in order to create drainage channels. These drainage channels were equipped with drainage devices made of boards, that could be opened and closed at will. The irrigation channels were created in shapes enabling linkage to the drainage channels, and they were devised in a manner whereby water flowed along the slope, horizontally and vertically. The water was then directed to fields (paddies) created for the cultivation of rice. The water that flowed into the paddy fields also created a flow, and on its becoming full the slope was used to direct the water to the field below. Thus, a system was created whereby water could be efficiently distributed to the paddy fields created on sloping land.

The kings of the Angkor dynasty searched for appropriate land, they created reservoirs in succession, developed irrigation canals, and increased rice paddies, in order to boost rice yields. This increase in rice harvest made it possible to feed larger populations. Such economic underpinning made possible the erection of temples like Angkor Wat and Angkor Thom, large-scale stone structures that mobilized hundreds and thousands of people daily and lasted for decades. The laborers engaged in the erection of these temples were not just Cambodians, but also Cham and Thai people who were brought into Angkor as prisoners of war, and compelled to work. It is said there were many slaves as well from neighboring nations such as Laotians, who were brought to work as prisoners of war, and people of a mountain minority dwelling in the vicinity also willingly became workers, on hearing that food would be offered to them.

The Angkor dynasty which lasted for over 6 centuries, came to an end. Viewed from a macro perspective, one may point out that there was a change in trade routes, due to major technological innovations. With the emergence of large sailing ships, mainstream trade came to be conducted using large ships and the sea, rather than using small boats and small and medium-size rivers. With this change in trade routes, nations with ports facing the open sea commenced thriving in global trade, while the significance of the Angkor dynasty, which was located inland and conducted trade by the use of small and medium-sized rivers, began to decrease. This external factor is not the sole cause of its disappearance, since there also exist two possible internal causes. The first is the fact that vast amounts of timber were utilized for the erection of the temples. This subsequently led to deforestation, and deforestation in turn led to the degradation of the soil. The mineral content of the forest was lost, and this in turn led to a drop in the soil's quality. Also, the water retention capacity of forests began to decrease, resulting in a fall in the volume of water in rivers, as well as the groundwater. Permit me to explain this in a more detailed manner. In the rainy season the trees in the forest retain water, and the soil, which has amassed dead leaves and other such matter, also stores water and gradually distributes it. As deforestation proceeds, the rainwater just flows away. Also, during the dry season, the land comes into direct contact with the rays of the sun, thereby causing the soil to dry. Hence, the amount of water entering rivers, groundwater, and reservoirs as a whole falls. The second cause is the accumulation of mud in reservoirs and irrigation canals. Most of the soil in the Siem Reap area is sand mixed with clay, and it takes time for the soil to become muddy. Nevertheless, over a period of decades it gradually settles at the bottom, and so the amount of water in the reservoir drops. The records reveal no evidence of dredging. As the volume of water in the reservoir decreases the volume of water flowing into the irrigation canals decreases as well, as does the velocity of the water flow. Hence, in the irrigation canals as well, mud accumulates. What occurs is a sort of irrigation canal arteriosclerosis phenomenon. As a result, the amount of water in the paddy field gets reduced, the speed of the water flow gets reduced, and the flow of water to the paddy field below is also reduced, and it also slows down. This negative chain of events occurs in succession, leading to a decrease in the rice yield.

However, the slowing down of the water flow gave rise to an alternate type of negative effect. Mosquitoes commenced thriving in vast numbers due to the water retention, and this in turn resulted in large numbers of people getting infected with malaria. As one can imagine, getting infected with malaria in situations where food conditions had declined due to a fall in rice production, could give rise to cases where workers lose their resistance and grow unable to work. In other words, the hydraulic city grew incapable of managing its water, the water supply in reservoirs fell, and the arteriosclerosis of irrigation canals reduced rice yields, thereby making the upkeep of a large population impossible. Also, diseases like malaria that were spread by vast numbers of mosquitoes in stagnant water began to circulate, and this in turn led to a big drop in the labor force of workers and soldiers, thereby causing a decline in the very empire itself. The above is the gist of the "Hydraulic City," where Grolier explained the creation, growth, and fading away of the Angkor empire, from a socio-economic perspective. The subtitle, "Development or Over-development" indicates that "development" enabled the erection of a great empire, through the good use of water. Yet the scale of development grew greatly, causing deforestation, accretion of mud in reservoirs, "arteriosclerosis" in irrigation channels, and diffusion of diseases like malaria through large numbers of mosquitoes, a phenomenon caused by stagnant water. The author understands the question as asking whether one of the causes of the empire's downfall was "over-development."

Professor Georges Condominas, my mentor in France who personally knew Groslier, praised Groslier's triumphs in the following words. Groslier's Hydraulic City theory was stimulated by the concept of the 'total social phenomenon' of Marcel Mauss, and inspired by the 'long-term' theory of Fernand Braudel, a founder of the Annales school. It is based on an entirely new anthropological theory created by Groslier. At the basis of this lies his academic background in archaeology, art history, history, ethnology, architecture, and so on that he had acquired since he was a youth, and most of all, his experience at several on-site archaeological excavations at diverse sites among the Angkor ruins. Besides, his father was the founder of the National Museum of Cambodia, and he himself was born in Cambodia. It is precisely due to his deep love for Cambodia and familiarity with the nation since childhood, that this new academic synthesis and new “Hydraulic City” theory was born.”

2. The Sophia University Angkor International Mission Team

Since the period of the Angkor Dynasty, Cambodia has had a complex history. The nation’s territory was invaded by adjacent powers such as Thailand’s Ayutthaya Dynasty and Vietnam’s Lai Dynasty and Nguyen Dynasty, whereby its territory was reduced to about half of what it used to be in the glory days of Angkor. In 1863, Norodom, the King of Cambodia, voluntarily sought the protectorate status of the French, so as to evade the dual vassalage status of Thailand and Vietnam. Later, when the “French Indochina Federation” was created as a united version of present-day Vietnam and Laos, Cambodia became part of the Union. In 1955, owing to the efforts of Norodom Sihanouk, Cambodia finally gained independence, and the Kingdom of Cambodia was instituted. However, when the Vietnam War was fought as a “fierce battle” amidst the Cold War, Cambodia was embroiled in the vortex. In 1970, pro-American General Lon Nol staged a coup d’état. He exiled King Sihanouk and formed the “Khmer Republic.” However, when North Vietnam led by President Ho Chi Minh won the Vietnam War, the Khmer Rouge, a communist group in Cambodia who were greatly inspired by China’s Mao Zedong ideology seized power, and in 1976 Democratic Kampuchea led by Pol Pot was formed. They then put into effect a very proto-communist system. Over two million people including intellectuals and civil servants were allegedly killed or otherwise died under dubious circumstances, and over 5 million Cambodians are said to have fled the nation. Amidst the slaughter of the populace, pro-Vietnamese Heng Samrin seized power from the Khmer Rouge with the aid of the Vietnamese army, and the People’s Republic of Kampuchea was founded in 1979. Three distinct political forces who were opposed to this pro-Vietnamese government [that is, Sihanouk (royalist), Song San (liberal), and Pol Pot (communist)] joined forces to form the “Three Democratic Factions” to oppose the Heng Samrin regime, and so the end result was that the civil war persisted. In 1986, the Vietnamese army withdrew totally from the country, and the situation altered. In 1990, the Japanese government stepped in and organized the Tokyo Conference on Peace in Cambodia, to which all concerned parties were invited. The United Nations also took part. A governing body entitled the United Nations Transitional Authority in Cambodia (UNTAC) decided to rule the nation as an interim measure, and conduct the general elections. Akashi Yasushi, a Japanese national, was appointed Secretary General of the UNTAC. General elections were conducted in 1992, the “Kingdom of Cambodia” was established in 1993 with Sihanouk as King, and at long last, peace and stability appeared in Cambodia.

Professor Yoshiaki Ishizawa was a graduate of the French Language Studies Department, of the Faculty of Foreign Studies of Sophia University. However, in the summer of 1959, while in his third year at the university, he was guided by a French professor to Cambodia in order to undergo French language training. Even prior to that he had developed a deep interest in Angkor Wat, but when he finally visited the monument, he received a shock that astounded him. At that time, Cambodia which had just been liberated from French colonial rule was known as a small and weak nation. Nevertheless however, people were stunned at the fact that over 1000 years earlier they had erected a temple, that was so indescribably large. Who was it that had erected such a massive temple? What were the reasons for doing so? How was it erected? These were the issues that arose within his mind, and he was seized with an intense desire to try and solve the mystery. Later he came upon certain EFEO experts stationed in Cambodia in order to pursue their research, and he realized that if he learned to ask and answer questions in French, master the Cambodian language using French as a means, and study academic methodology, there were chances of his becoming a full-fledged researcher of the Angkor ruins. At the same time though, while at the EFEO he felt uneasy at the attitude adopted by the French towards the Cambodians. The French who had ruled the colony for over 80 years as suzerains possessed a lofty viewpoint, and a sense of disdain for the Cambodians. They clearly manifested an attitude that stated, "Anyhow the Cambodians of today are unable to conserve or restore the Angkor ruins. It is up to us French people of the suzerain nation of France, to take responsibility for the restoration of the Angkor monuments." Being a Japanese and fellow Asian, he was convinced that he could help Cambodia.

He altered his course of study to history and majored in history at the graduate school of Chuo University, and as a graduate student he visited Cambodia numerous times during vacations and confirmed his academic origins. He then concluded his doctoral dissertation on Cambodian history and gained a Ph.D. Likewise, he went to France to study at the EFEO, and as a disciple of Cœdès he learned to decipher stone inscriptions from the Angkor dynasty, thereby becoming one of the few Cambodian experts in Japan.

There was a limit to doing research on Cambodia in Japan due to the paucity of materials, and hence it became necessary to conduct research at the site, including the gathering of materials. Accordingly, from 1980 when the civil war still raged, he seized every occasion to travel to Cambodia, risking his life and collecting as much first-hand information as possible. In the meantime, he deepened his bonds with those Japanese who loved Cambodia, such as Mr. Yukio Imagawa, a Cambodian expert and diplomat who later became Japan's Ambassador to Cambodia, and debated as to how cultural and educational activities of conserving and restoring archaeological sites, may be linked to peacebuilding and cultural revival in the nation. Furthermore, discussions were held with the Department of Site Conservation of the Ministry of Culture of Cambodia, the Faculties of Archaeology and Architecture of the Royal University of Fine Arts, and other bodies linked to the conservation and restoration of the Angkor monuments, in order to determine specific ways whereby cultural cooperation between Japan and Cambodia may be promoted. It was also established that while in the 1960s there were around 80 Cambodian conservation officers caring for the Angkor ruins, it turned out that only three were alive as of 1990, due to the civil war and the massacre of Pol Pot.

In 1991, while in the process of achieving peace in Cambodia, a fact in which the Japanese government also played an active role, there arose a growing momentum among those involved, regarding the need for Japan's cooperation in the cultural field. Accordingly, the Sophia University Angkor International Mission Team was formed under the leadership of Professor Ishizawa, and it was decided to commence a full-scale field survey. The author also joined in this survey team as a deputy leader from the very onset and set foot in the field. Although 1991 was a year when the civil war had finally concluded and peace had returned to Cambodia, the scars of the war were deep and wide. The people of the Siem Reap Province where the Angkor ruins are located were poor, and most of the time they survived with just a single shirt. The buildings were old, and there seemed to be no way of restoring the damaged areas. On recognizing foreigners, beggars and people with a few fruits or vegetables in hand would gather around imploring, "Give me a dollar! Please buy this from me for a dollar."

The excavation, conservation, and restoration of the Banteay Kdei temple erected in the 12th century, was commissioned by the Archaeological Conservation Department of the Ministry of Culture. On account of its having been abandoned for decades, the temple became thickly overgrown with grass and trees. First of all, they had to be discarded, and later the 3 basic principles of archaeological conservation had to be applied. The three principles are as follows: (1) Removal of rainwater from the ruins. (2) Removal of buds from trees. (3) Removal of black mold. Hence, after talks with Director General Song Kong of the Heritage Conservation Department, we decided to request residents of adjacent villages to engage in part-time jobs, such as cutting grass and wood. It was a great opportunity for the residents to acquire some income from working at places in the immediate vicinity, and for us as well to interact with the local people. What we hoped for was that even in the absence of the survey team, the role of conserving the Banteay Kdei site would be carried out.

Also, 10 students each from the Department of Archaeology and Department of Construction at the Royal University of Fine Arts in the capital city of Phnom Penh were invited to participate, and their travel and accommodation expenses were of course paid for by the research team. In Cambodia, which was a nation engulfed in war, none could afford to travel from the capital city of Phnom Penh to the Angkor ruins in the Siem Reap Province located on the opposite shore of the Tonle Sap Lake, for sightseeing. Hence, all the 20 students who had entered the departments of Archaeology and Architecture of the most highly selective university in Cambodia, with dreams of building a career in the conservation and restoration of the Angkor monuments, had never yet had an opportunity of seeing Angkor with their own eyes. Bringing along those students as part of the on-site training, also happened to be a hidden purpose of ours. On speaking to the students, we realized that owing to the war-torn situation, they were not even receiving sufficient lectures. Accordingly, we decided on a trial basis to provide the students with the lectures they desired at the site. Fortunately, however the study team was comprised of experts in archeology, architecture, and other fields, and so we had a system in place to respond to the needs of the students. As the lectures were well received, it was decided at the meeting that from the following year onwards, offering intensive lectures at the Royal University of Fine Arts would constitute one of the missions of the research team. The need for adequate preparation for those lectures, was also discussed.

In August 1992 and 1993, the survey team remained in the area for activities focusing on the excavation, conservation, and restoration of the Banteay Kdei temple. For students of the departments of Archeology and Architecture intensive lectures became the norm at the Royal University of Fine Arts, and we also visited other temples at the Angkor sites such as Banteay Srei, Preah Khan, Angkor Wat, Angkor Thom, the Bayon, and so on. We also continued discussions with Director General Song Kong, of the Archaeological Conservation Department.

As an outcome of this, the basic line of activity of the research team was made public in the form of a creed, that is to say, under the slogan: “The conservation and restoration of the Cambodian monuments should be carried out by the Cambodians, for Cambodians,” and the research team decided to offer full support for the realization of this slogan.

In consultation with Japan’s Ministry of Education, Culture, Sports, Science, and Technology, we cleared the way for Cambodian students to study at the graduate school of Sophia University, as exchange students of the Japanese government. So far 17 Cambodian students (6 with doctoral degrees and 11 with master’s degrees) have studied at the Graduate School of Sophia University, and currently, they work as specialists at Cambodia’s Ministry of Culture and Archaeological Conservation Bureau.

Following the results of the general elections conducted by UNTAC, the new “Kingdom of Cambodia” was born in September 1993. This new Cambodian regime had a heap of issues to deal with. Yet they opted to organize a fresh system, so as to tackle in earnest the conservation and restoration of the Angkor ruins. This was the National Authority for Protection and Management of Angkor and the Region of Siem-Reap. Its acronym is APSARA (a word signifying a celestial maiden or angel in Cambodian), it was officially instituted in 1994, and its president was the famous architect Vann Molyvann, who also served as the Minister of Culture.

In 1994, Mr. Yukio Imagawa, the Japanese Ambassador to Cambodia, kindly granted me an opportunity to report directly to His Majesty King Sihanouk, on the activities of the Sophia University Angkor International Research Team. As deputy leader of the team I was honored to visit the royal palace along with the team leader Professor Ishizawa and Ambassador Imagawa, and have a direct interchange with His Majesty King Norodom Sihanouk.

In 1995, we of the research team were commissioned by APSARA to work on restoring the western approach to Angkor Wat. At long last peace had been restored in Cambodia, and people the world over were inundated with hopes of visiting the Angkor monuments. The Cambodian government too was desirous of establishing a system whereby tourists could be welcomed from nations around the world, and of using this as a support to economic development. Angkor Wat being the focus of the flood of tourists, fortifying the approach to the temple and ensuring the safety of the tourists, was an urgent issue.

In response to this bid by APSARA, the research team enlisted the cooperation of architectural restoration specialists and specialized institutions throughout Japan, and formed a body that worked on an “all-Japan” basis. Commencing with Professor Masao Katagiri of Nihon University’s Faculty of Engineering who sponsored us, a support system was organized with the cooperation of researchers such as Professor Yoshio Moriai of Tohoku Institute of Technology, Professor Kunikazu Ueno of Nara Women’s University, and national research institutes like the Nara National Research Institute for Cultural Properties and Tokyo National Research Institute for Cultural Properties. In 1996, we purchased a house in the Siem Reap Province and established the Sophia Asia Center for Research and Human Development of Sophia University, with the intention of establishing a base over there.

Professor Yoshiaki Ishizawa continues to serve as director of this center, to this very day. The first phase of the restoration of the western approach to Angkor Wat that began in 1996, took 12 years from 1996 to 2007. The western approach is 200m long and 12m wide, but the right half of it was restored in the 1960s under the guidance of the French from the EFEO. However, the remaining left half remained as it was when the Angkor temple was erected, and passage through it was forbidden. Half of this length, namely about 100 meters, was restored during the first phase of construction by a global team comprised mainly of Cambodians and Japanese. The reason for its having taken 12 long years, was because it was necessary to employ the same construction methods and materials used at that time, in order to ensure authenticity. That is to say, it took time because the research and restoration work had to be conducted concurrently. The second phase of construction to restore the remaining 100m commenced in 2016. Unfortunately, however, due to the global outbreak of new coronavirus infections, the originally scheduled construction period had to be extended.

The Sophia Asia Center for Research and Human Development has specified and is currently implementing, the following seven projects.

1) Human Resource Development (archaeological excavation, architectural conservation science, community leaders, and so on).
2) Restoration of the Western Approach to Angkor Wat (clarification of construction techniques).
3) Historical Elucidation Research through the Archaeological and Architectural Surveys of the Angkor Dynasty.
4) Promoting ASEAN South-South Cooperation through the Restoration of Cultural Heritage.
5) Cultural Heritage Awareness Education (school trips for elementary and junior high school students to archaeological sites, public awareness lectures) and Activities for the Preservation of Intangible Cultural Properties.

6) Environmental Conservation and Promotion of ISO14001.
7) Training and Exchange of the Next Generation Leaders in Japan and Cambodia.

In 1997, the Japan International Cooperation Agency (JICA) succeeded in creating a 1:5000 topographical map of the Angkor region. This was done by taking satellite photographs, with reference to the technical cooperation for agricultural development in Cambodia. In August 2007, an international research team of the National Aeronautics and Space Administration (NASA) entered the Angkor area. They brought in image analysis equipment with a resolution of less than one meter and high-resolution radar, to confirm and publicize on site the remains of water facilities and waterways dating from the Angkor Dynasty (9^{th} –15^{th} century).

The Sophia Asia Center for Research and Human Development of Sophia University decided to obtain a topographic map at 1/5000 scale produced by JICA, in order to create a detailed three-dimensional model of the topography. They also obtained materials created by NASA, and are using them as reference historical material.

By means of these detailed three-dimensional topographies, it was proved that the ‘over-the-field irrigation’ system described by Groslier, had in point of fact been implemented.

3. Japan-Cambodia Cooperation and Continuance of the EFEO’s Academic Achievements

In Cambodia, an assortment of regimes has acquired power and successively established states, and yet all of them have used Angkor Wat in their flag designs. Although the designs may differ in accordance with the regime, yet there is no doubt at all that Angkor is conceived as a “cultural symbol” of Cambodia, and as a “font of pride” and a “spiritual support” for the nation’s people. Along with the Greek Pantheon and the Roman Amphitheatre Colosseum, the Angkor Complex is a top-class human heritage site unequaled in the world, a cultural value that is recognized by everyone the world over, regardless of nationality.

When the Sophia University Angkor International Mission Team first visited Cambodia in 1991, a key issue in discussions with the Ministry of Culture was the question as to ‘how the Angkor Archaeological Complex could be registered as a UNESCO World Heritage Site,’ and on that occasion, the author was also present. In order to apply for registration as a world heritage site, one needs first of all to develop domestic laws, and grant places like national parks and so on a high local evaluation. It is also essential to establish a system for the security and supervision of the budget and personnel associated with the venture. However, in war-torn Cambodia, neither laws nor protective management systems existed. Hence, our first priority was to establish national laws and a security and supervision system. The next issue was concerned with the concrete procedure of the application. Concerning the manner of writing application documents and process of application, those in the Cambodian Ministry of Culture were inexperienced, and none knew what needed to be done. To provide intellectual assistance to the Ministry of Culture, the author contacted the UNESCO World Heritage Committee based in Paris and requested the cooperation of the officials, stating that the Cambodian government was eager to have the Angkor Complex inscribed on the World Heritage List, that the Angkor Complex possessed a symbolic significance for the restoration of peace and birth of the new Kingdom of Cambodia, and so on. The members of the UNESCO World Heritage Committee welcomed us favorably, and kindly initiated us regarding the methods and processes for the application and registration. I returned to Phnom Penh from Paris with the information, and directly worked with the officials of the Ministry of Culture so as to expedite the application process. Around the end of 1992, with unusual speed the World Heritage Committee issued a verdict favoring the registration of the Angkor ruins as a World Heritage Site, though with certain conditions. The condition insisted on was that an agency be formed at the earliest within Cambodia for the supervision and security of the Angkor ruins, and that the control and safeguarding of the ruins be carried out in earnest. It was in response to the requisites of the UNESCO World Heritage Committee, that the APSARA (National Authority for the Protection and Management of Angkor and the Region of Siem-Reap) was constituted.

Through this World Heritage registration, bonds of mutual trust between the Cambodian Ministry of Culture, the APSARA authority, and the research team, were fortified. The Apsara Authority had a great dearth of first-rate conservation officers, and so the training and securing of such personnel became an urgent issue. President Vann Molyvann also had often asked Sophia University to train future conservation officers for the Angkor Complex. In response to this and after talks with the Ministry of Education, Culture, Sports, Science and Technology, we paved the way for them to enter Japan and study at graduate schools, as Japanese Government scholarship students. While in the graduate schools they registered for courses in conservation science, archaeology, architecture and so on, and earned master’s and doctoral degrees. To date, 17 Cambodian students have gained master’s and doctoral degrees, and many occupy key positions such as Deputy Director of APSARA, Director of the Conservation Department of the Ministry of Culture, and Director of the National Museum.

The achievements of the EFEO in Cambodia include the publication of major books and papers centered around Professor Ishizawa, which have been translated into Japanese. Let me present some notable examples. A major work of Cœdès was, Les états hindouisés d’Indochine et d’Indonésie (Paris, 1964). Barely 5 years later in 1969, Misuzu Shobo issued an overview of it entitled, “A History of the Indochinese Civilization.” The complete translation was published in 1989 as “A Cultural History of Southeast Asia,” (Okura Publishing Co., Ltd.). Also, a major work of Groslier was “Angkor et le Cambodge au XVI^{e} Siècle, d’après les sources Portugaises et Espagnoles,” (P.U.F. 1958), [“Angkor and Cambodia in the 16th Century according to Portuguese and Spanish Sources”]. In 1960 this work was translated by Yoshio Kanayama and published in the “Toyo Gakuho,” a bulletin of Toyo Bunko. However, as this was a document meant to be read by specialists, Professor Ishizawa co-translated it with Setsuko Nakajima and published it as a book for the general reader as, “Angkor as seen by the West: Prosperity and Decline of the Hydraulic City,” (Rengo Shuppan, 1997).

In 2003, an academic agreement was signed between the EFEO and Sophia University. In Angkor, Sophia University was in charge of the Banteay Kdei Temple, and the EFEO was placed in charge of the Western Baray (reservoir). The EFEO was conducting research with several French members in residence. Until the period 1991-1995 when Sophia University dispatched a research team, a system whereby people were permanently stationed was not yet created, and they sought to establish a residential system modeled after the EFEO. Fortunately, though, after procuring a house and launching the Sophia Asia Center for Research and Human Development in 1996, we were finally able to establish a system with several residential staff members.

However, as the French government’s national budget decreased and cultural reductions grew greater, the EFEO was obliged to close its Angkor field office in Cambodia in 2019, and so it was decided that they would retire from the conservation and restoration activities of the Western Baray. Thus, Sophia University remained the sole body that had been engaged in the conservation and restoration activities of the Angkor ruins since many years, and its responsibility had now increased.

This time, the aim of the organizers of this second international symposium focusing on the Groslier’s theory of the Hydraulic City, is to confirm the fact that the Sophia University Angkor International Research Mission and the Sophia Asia Center for Research and Human Development, need to meticulously inspect and pass on the results of the research of the Angkor Complex, that the EFEO has researched and analyzed for over 70 years.

Groslier’s theory of the Hydraulic City aims to clarify the system of the entire Angkor Empire, on a large scale. Analysis of aerial photographs from space by JICA and NASA, that make full use of modern advanced technology, revealed aspects that actually confirmed Grolier’s hypothesis. In the future, it will no longer be merely the academic findings of the EFEO. It is also crucial to correctly analyze and pass on to future generations the conservation and restoration skills for buildings, reservoirs, roads, encircling moats, bridges, and other structures at Angkor, that were developed over the years. Accordingly, the guidelines for our future activities can be classified into the following five points.

(1) Groslier’s theory of the “Hydraulic City” will be applied geographically into small groups, and utilizing advanced technology such as aerospace photography, we will create more detailed three-dimensional topographic maps, correctly measure the water flow and water volume, and verify Groslier’s “Hydraulic City” theory in detail.

(2) As regards Angkor Wat, while working on the second phase of the construction of the western approach, we will conduct an in-depth examination of the benefits and minuses of the “Anastylosis Method (reconstruction method of the ancient Greek Pantheon columns)” used by the EFEO, which was clarified in the first phase of the construction, and decide whether to apply

that method. In parallel, we will promote research on restoration techniques for the approach.

(3) In anticipation of the return of tourists from around the world to Angkor in the post-corona era, we will cooperate with the APSARA Authority to carry out a general inspection of the monuments, temples, moats, approaches, bridges and other features that could not be dealt with for conservation and restoration for over two years, due to the coronavirus disaster. A safety map will be created for the entire Angkor Complex, and warning boards will be installed in unsafe areas.

(4) In addition to bolstering the study-abroad system in Japan for the training of Cambodian conservation officers, efforts will be made to increase the number of Cambodian students studying abroad, by appealing to France and other nations advanced in archaeological restoration.

(5) We will play a role in promoting the “ASEAN South-South Cooperation” project as coordinators, wherein experts and trainees from ASEAN nations like Vietnam, Thailand, Laos, and Indonesia, which have stone monuments, will be invited to the conservation and restoration sites of the Angkor monuments for on-site training.

With this, I conclude my report, and I have a final request for all of you. Sophia University is a private institution, and the Sophia Asia Center for Research and Human Development is basically financed by crowdfunded donations, from those who have a feeling of empathy with regard to this project. Of course, we also receive occasional aid from the Ministry of Culture of the Government of Japan, the Japan International Cooperation Agency (JICA), the Japan Foundation, and other public bodies. Nevertheless, though, the Angkor ruins are a group of a massive scale, their conservation, restoration, and research are in need of vast amounts of time and personnel. So far, this project has been urged on by Professor Yoshiaki Ishizawa’s astounding patience and passion with regard to Angkor, and even now at the age of 85, he continues to struggle. I however am confident that he will continue to toil hard for the conservation and restoration of the Angkor monuments for another 15 years or more, until he has exceeded the age of 100.

In order to pass on this project to future generations, it is vital that the younger age group of Japanese researchers, engineers, and conservation officers take the reins. For this purpose, all of Japan needs to unite, and it is vital that we have adequate donations and sponsors, so that Professor Ishizawa will feel that it is safe to entrust the project to future generations. We once again sincerely request you for your kind understanding and wholehearted support, for the conservation and restoration project of the Angkor monuments.

問題提起（2）

「JICA（国際協力事業団）のコンピューターから田越灌漑の畦道を発見」

石澤良昭（上智大学アジア人材養成研究センター所長）

本日、共同オーガナイザーの坪井善明先生に、これまでのB.P.グロリエ先生のご紹介をいただきました。次にNASAの調査を担当しましたローランド・フレッチャー先生にはシドーニーから駆けつけてくれました。2007年8月にNASAの調査を担当されました先生です。次にフランス極東学院のスーティフ先生には現地シェムリアップからご出席いただきました。碑刻文研究の専門家です。第3番目にはカンボジア王国政府のアプサラ機構総裁としてご公務でご多忙中のところ、ご出席いただき、ありがとうございました。水利都市研究の専門家です。最後にフランス極東学院の研究部長のC.ポチエ先生からメール・メッセージがあります。タイのチェンマイから届きます。

（1）航空測量の地形図が約900年前の史実を看破する

JICA（日本国政府国際協力事業団）の5000分の1地形図は、B.P. グロリエが提起した「Cité Hydraulique（水利都市）」の概念とその集約農業経済によるアンコール王朝の栄華を立証すると同時にその史実を裏付ける学術データを提供してくれました。アンコール地域では雨水に加えて、シェムリアップ川をはじめ中小河川が流れており、巨大なバライ（貯水池）などが2ヵ所に造営できました。現在も当時の遺構として見学できます。当時このバライを使って、いくつもの大きな水田に田越し灌漑が実施され、年に2回収穫できる集約的な農業生産が曲りなりにも約600年にわたり実施されていた。

このJICAの5000分の1地形図からは、たくさんの史実情報が確認できた。例えば、旧道路、堤防、橋、建物跡、旧河床などがはっきり浮かび上がってきた。地形図から判明する史実はかなり具体的で説得的である。大扇状地とバライ、それに田地・河川・河床・堤防・橋梁・洪水跡・小堤・畦道などを800年間の時間と空間を越えて捉えることができた。この地形図を解読することで、当時のインフラ関係の敷地跡や村の日常生活の家宅跡、そして田地の区画などが判明してくる。今回のシンポジウムではアンコール王朝がどのような経済活動により繁栄したかについて一つの回答を出したことである。『王朝年代記』などを書いた貝葉史料が失われ、どうしても歴史の詳細が謎になりがちの、約800年前の古代史に一筋の光明を与えたことになる。ただここで残念なのは、「水利都市」提唱者のB.P.グロリエが逝ってしまったことである。

（2）5000分の1の地形図データ─微高地形図を40倍に引伸ばす─

JICAは、カンボジアの農業開発技術援助協力プロジェクト（正式名称：カンボジア王国シェムリアップおよびアンコール遺跡公園地形図作成調査（1994～1998年）を実施した。このプロ

ジェクトは国際建設技術協会および国際航業（株）が受注し、専門家アドヴァイザーとして灌漑工学の宇都宮大学農学部教授の後藤章先生が中心となり、アンコール地域の現場情報を提供する石澤および現地の映像を番組化する NHK ディレクター井上勝弘氏が加わり開始された。その膨大なデータが集積され、現地で遺跡調査研究中の私もその一部を拝見し、解像度等の鮮明なデータに驚きました。これまでに定期便で上空から遺跡群を見たことがあったが、目の前にコンピューター･グラフィックの生（ナマ）の地形図データを拝見したのは初めてであった。データには大小の遺跡と共にプノン・クーレン高丘からトンレ・サープ湖岸に広がる大扇状地上には、田地・道路・大小の河川と池がくっきりと浮かびあがり、驚愕したのを覚えている。丁度その時期であるが、NHK からアンコール・ワットの記録映像作成の協力要請があり、その準備をしていたところでもあった。早速、この JICA の地形図プロジェクトを NHK の担当者（井上勝弘ディレクター）に話をしたところ、話がまとまり、NHK テレビ・チームと共に現地データを収録のためカンボジア現地へ赴きました。そして NHK 総合テレビ「アンコール・ワット - 知られざる水の帝国」として 1997 年 11 月 16 日放映され、大好評を博しました。

では、当時のアンコール時代の人々はどうやってこの水利灌漑を使用したのであろうか。この 5000 分の 1 の地形図では、ほぼ 15 メートル間隔の等高線を描くことができる。私たちはこの地形図に盛られたデータに基づき、アンコール地域の地形図をコンピューターグラフィックスを使って立体的に描出することで、アンコール時代の灌漑方法を探ることができた。

私たちは地形図の等高線のデータを都城のほぼ全域にわたって立体化した。アンコール地方は起状がほとんどない板のような地形であることがわかった。しかし、アンコール時代の灌漑の痕跡を探るため、微高地形図の高低差を 40 倍に引伸ばして再現してみると、貯水池の堤防と並行して細い線と点がほぼ同じ間隔で並んでいるのが確認できた。これこそ地面を人工的に盛り上げた往時の畦道跡である。それらの人工の盛土は、後世において一部もしくは大部分が流出し、確認の難しいところもある。

水平にすると、アンコール地域の地形は北から南にわずかに傾斜していることがわかる。大づかみにいえば、そこは大昔、シェムリアップ川により造られた大扇状地であり、その傾斜は水平距離約 1.5 キロに対し標高差 1 メートルあまりである。カンボジアの人々はこのわずかな自然の傾斜を発見し、それを利用して、あの広い大扇状地全体に水を行き渡らせていたのである。

(3) 巨大な「田越し灌漑」がつくられた

シナリオはこうだったのではないか？乾ききった季節、貯水池の堤を切る（堤防の調査は未済）と、傾斜に沿って水はゆっくり流れていく。さらに下の土手を切れば、水は低い方に落ちていく。土手に囲まれた大区画を一枚の田として田植えを行い、稲が根付いたら最小限の水を残してその水を下位の次の囲いの水田に下ろしていく。これこそ巨大な「田越し灌漑」といわれるものである。

これはあくまで一つの仮説であるが、当時のカンボジアの人たちは世界にも類例のない独自の灌漑方法を編み出すことで、乾季の干上がってひび割れた田地の悪条件を見事に克服していたと考えることができる。アンコール王朝時代、村人は王の指示のもと、貯水池の堤防を切り、数キロにもわたる水田で一斉に田植えを始めていた。最初の田地の田植えが終われば、下位の

大水田に残りの水を流し、次の水田の田植を開始した。こうして大水田がつくられた。次に穫り入れを行っていた。もし1年に2度も繰り返されていたとするなら､この田植えとその収穫は､アンコール王朝に大発展をもたらした。食糧の安定的な増産は人口増につながった。例えば建寺作業員とその家族が各地から徒歩や牛車に乗ってアンコール都城近くへ集まってきた。カンボジア人村人は王への奉仕税（ラージャカールヤ）として寺院造営現場に来ていた。もう一つの理由は「ごはん」が食べられることではないかと推察されている。カンボジアでは春の冷え込む時でだいたい27度である。造営寺院の近くに掘立て小屋を造り寝泊まりしていた。重労働とはいいながら、十分な食事が供与されることが何より魅力であったと思われる。風評を伝えきいた近隣の人たちはもちろん、遠くに住むクメール人、シャム人、チャム人、モン人、ミャンマー人、中国人、ラオ人、山岳少数民族たちまでが集まってきたと思われる。カンボジア人にとっては寺院建設に参加することは一つの功徳であり、極楽浄土行きの切符であった。

王がクーレン高丘系からトンレ・サープ湖岸まで広がる大扇状地を建国の地に選んだ理由は、「水」が確保できることにあったと思われる。クーレン高丘山系からいつもシェムリアップ川の流水が注ぎ込まれる広大なアンコールの大扇状地であった。

（4）NASA国際調査チームが「水利都市」の存在を証明した

その後、本日ご出席のローランド先生のNASA国際調査チームが2007年8月にアンコールの水利調査のため到来し、解像度1メートル以下の画像解析機器と高解像レーダーを持ち込み、アンコール王朝時代（9～15世紀）の水利施設と水路跡を現地で確認し、公表した。例えばバライ所在地の地形、バライ、水路の痕跡、田地跡などの総合的な調査であった。その結果、アンコール都城にはかつて1000キロにも及ぶ、大規模な水路が稼働していた史実を突き止めた。バライの取水口や排水口が再確認され、その水路から周辺地域の田地へ水を流していたことも確められた。当時、最盛期の人口が100万人を超えていたかもしれないという仮説も提案されました。この水利都市の開発が、王の強い意志で稼働していたことも確認したという。

このNASAおよびフランス極東学院の国際調査チームの報告は､フランスの『フィガロ紙』(Le Figaro, 2007年8月13日付）に「アンコール都城における大規模な水利施設の活用」（Une hydrographie de grande envergure à Angkor）の見出しで、その調査の全容が報道された。さらに前述したNASAの調査成果を『ナショナルジオグラフィック』（National Geographic、日本版第15巻第7号2009年7月号）では特集し、調査に参加した専門家2名のインタビューにもとづき、誌上で「アンコール王朝の興亡」という調査写真データを掲げ、水に支配された都城の残影の写真を掲げている。田地に配水する水路跡を確認し、地域の全人口は75万人ぐらいであったという。そして西バライ（2キロ×8キロ）の築堤のために、20万人の土木作業員が動員されたという。これも、グロリエ水利都市論を裏付ける論証であった。

（5）時空を超えて語りかける無言の使者「アンコール・ワット」

当時の篤い信仰を可視化した巨大な石造伽藍アンコール・ワット、当時のカンボジア人が最高価値と位置づけた寺院、その空間形状は極楽浄土に似た建物といわれてきた。奥地のジャングルを背景に、忽然と光輝く黄金の大尖塔は、来訪者や村人たちの度肝を抜いた。その気持ち

を言い表すとすれば、「アンコール・ワットの空の先に極楽浄土があるにちがいない」というほどの感動だった。アンコール･ワットの5基の大尖塔、幅200メートルの大環濠、三重の大回廊、天空に届きそうな大階段、それに65メートルの大尖塔これは、誰が見てもこの世のものとは思えない、それほど迫力があり、自分が今どこにいるのかを忘れさせてしまうほどの、臨場感があった。この尖塔は、インドからもらった宇宙観をカンボジア流に翻案し、カンボジア人が考えた新しい宇宙世界そのものであり、彼らが創り上げた天空の楼閣だった。

これを灌漑と当時の王朝の富国強兵策とインフラ・ストラクチャーの観点から考えてみたい。このアンコール・ワットの大環濠の水のシステムは、雨季と乾季というカンボジアの気象条件を前提に、貯水する池水でもあった。貯水池（バライ）があり、灌漑システムが機能していた。雨期が6ヶ月続いたあとに、乾季には田越灌漑方式により、第2期作の田植えをしていた。この灌漑方式は農業生産の大増産につながり、大人口の生活を可能にしていた。それは富国強兵政策につながったのである。この大寺院には当時の村人たちが多く参詣し、信仰心を高めるという形で村人へフィードバックしていたのであった。

（6）大扇状地に展開する黄金の都城アンコール

B.P. グロリエ論文が1979年に『フランス極東学院紀要』（BEFEO）に掲載され、これまでその賛否をめぐり大論争が続いてきた。同論文は、アンコール王朝大繁栄の「経済活動」を裏付ける画期的論文であった。スールヤヴァルマン2世が登位した1113年頃の経済的背景を図式化すると、「貯水池（バライ）→二期作→食糧の確保→人口増加→寺院敷地の決定→作業員確保→着工」の仮説となる。王朝の大舞台となるこの扇状地は、北北東から南南西にかけて傾斜し、約1キロ行って約1.5メートル下がり、その下方では田地が何枚も耕作できた。これがアンコール王朝の集約農業の原点であった。扇状地の上部の高いところに貯水池（バライ）を盛土壁工事で造り、そこへ雨水や河川の水を引き入れ、バライの内側と外側に小溝をつけ、副水路とした。排水口から水路により田地へ給水された。王は37年かかってアンコール・ワットの大伽藍を造営した。しかし一部は未完成であった。その基礎部分は187メートル×215メートル、中央部の5基の尖塔の高さが65メートル（現在の9階建てのビルに相当する）。さらに環濠が幅が200メートル、周囲が5.5キロメートル、18段の敷石壁に囲まれ、約500万立方メートルの水量を貯えている。37年かけての大工事であった。

私たちは、B.P. グロリエ調査報告に基づき、さらにJICAが作製した5000分の1の地形図データを使ってグロリエの「水利都市論」をここに立証するものである。第1回目の「水利都市国際シンポジウム」は2000年に開催し、今回はその第2回目にあたる。1965年G. セデスが指摘した碑文の史料限界説を受けて、さらにNASAおよびフランス極東学院による綿密な科学的実地調査成果に基づき、巨大石造伽藍を造営できた当時のクメール人の民族エネルギーとその叡智を、ここに第2回国際シンポジウムとして「水利都市論」を議論するものである。

（7）籾米の配給の事例：13世紀のプリヤ・カーン碑文（K.908）を再考

プリヤ・カーン寺院の僧侶たちおよび寺院内で働く寺男・寺女に籾米が供与されていた記録が碑文に載っている。その籾米の重量計算単位がサンスクリット語の「カーリ（khāri）」で表示

されており、どれくらいの重量の籾米なのか。結論から言えば 1 カーリ（khāri）は約 96 キロであるという。プリヤ・カーン寺院では寺院内で働く寺男・寺女に対して籾米や食べ物の配給があったという記録である。①「高僧と見習い僧の許にいる召使い（寺男・寺女）に対して、無料で配給される籾米は 22 カーリ（khāri）である。」（碑文 L Ⅱ）：換算すると =2112 kg の籾米（米俵にして 35 俵）が届いていたという。その他、いくつもの配布事例が掲げられている。

（8）バライ（貯水池）の籾米を食べていたのは誰か

建寺作業員の主力は乾季に王への奉仕税（ラージャカールヤ）のために動員されたカンボジア人農民の数万人にのぼる作業員たちであったと思われる。建設現場でほかにたくさんのシャム人やチャム人、それにモン人、山岳少数民族などがいた。しかし、逃げ帰る人もあったと思われる。

外国人建寺作業員が常時数千人、あるいは数万人確保され、アンコール地域では次々と大寺院が造営されていた。アンコール地方の出稼ぎから戻った人または逃げ帰ったシャム人もたくさんいた。その中の有力者は、功徳のため寺院建立を、地元の有力者や土豪に進言していた。そして、自分自身のアンコールにおける建寺の経験を活かして、地元の寺院や祠堂の建設を手伝った。それ故に、チャオプラヤー川流域のスコータイ、アユタヤ、ロッブリー、それにマレー半島のタイ南部のプラサット・ムアンシン、南シナ海に面したチャンパ王国のミソン（ベトナム南部）に、アンコール建築様式系の影響を受けた石造り寺院や祠堂の建築が建っているのである。

B.P. グロリエの計算によれば、実際には、ハリハラーラヤ都城（9 世紀後半）に初めて貯水池が建設され、それは平地上に土塁堤防で囲い、貯水していた。10 世紀初めには東バライ貯水池（ヤショダラタターカ）が造られ、11 世紀にはさらに大きな西バライを造り上げた。この西バライは 4200 万から 7000 万㎥の貯水能力を持ち、1400ha の稲田を潤すことができたという。やがてアンコール都地域内に縦横に張り巡らされた水利網は、全盛期には 7 万 ha 灌漑していたという。しかしながら、当時のバライについての詳しい史料が欠落し、さらに、これら水路網の整備による米穀の生産高は正確にはわからない。誰がその籾米の恩恵を誰が受けていたのか、誰が食べていたのか、記録も消え、沈黙したままである。それでどんな人たちが籾米の配給を受けていたかを碑文史料の中から考察してみたい。

仮説ではあるが、バライ（貯水池）による二期作の集約農業の籾米を食べていた人たちは誰か、配給を受けていた人たちは誰か、考えてみたい。具体的に碑文史料から挙げていく。

（A）碑文に載った役職者や高官、その家族と召使い（奴隷的身分の人たちも）であった。彼らは称号と位階をもっている人たちであった。さらに宗務関係者とその家族、そして、下級官吏の人たちとその召使い（奴隷的身分の人たち）であった。

（B）建寺に関係する現場の特別職の人たち、それは石工を含めて石切場の採石人、石材加工技術者たち、建寺作業員たち、合計で数千人から数万人に及ぶと思われる。その工期が 10 年または 20 年に及ぶこともあった。アンコール・ワット建設の場合は 37 年に及ぶ。(c)『真臘風土記』に載るカンボジア人高官たちもそれなりの担当部署があり、米穀をもらいうけていたと思われる。

(9) 碑文は籾米の供与を受けていた人たちの記録？

これら食糧の供与を受けていた人たちは誰なのか、碑文史料および中国漢文史料に挙げられている王朝の構成員や浮彫に彫られた人々などを受益者と推定し、列挙してみたい。たとえば、遺跡の壁面浮彫りでは馴象を使った王国の大軍団が行進している。当時アンコール都城とその近隣に在住する人たちはどんな人たちであったか。当時の史料が貝葉に書かれていたが、消えてなくなってしまった。当時の人たちが言及した碑刻文（約 1200 点）から断片的な史料から拾い出してみると、以下の人たちが浮かび上がってくる。

少なくとも、日常的な米飯の供与を受けていたと思われる当時の人たちはどんな人たちか？都城とその近隣には、①回廊浮き彫りに描かれた王朝直属の常備兵軍団数十万人とシャームと称するシャム（タイ）人傭兵数万人、それに加えてチャム人義勇兵数万人など外国人兵員、②王の建寺熱に応える数百人の建築家がいた。その助手の作業員数千人と各地から来た土木・建寺作業員数万人、工匠、石工、石材施工師、石積み職人などが 20 万人の専門職集団、それに加えて、砂岩とラテライトの石切場数箇所で働く数千人の石工たち、③王と王家の人々、王、王子、王の弟、退任した王とその親戚一族、皇太后と家族に召使いの家族も、それに加えてそれぞれもとの家臣団、王家の家族、これを手伝う小官吏や召使、王族親戚を含む人たち数千人、④王宮内で働く高官たち、役職を持つ実務高官が数百人以上、侍典長、王族 4 家の高官（首相、法務大臣、王宮大臣、海軍大臣、陸軍大臣など）および多数の部下、走り使いの召使、地方の役務を実行する多数の実務高官とその部下、⑤もと王妃、王子、皇女たちと侍女たち、監視役女官、王の複数の妻妾、その子女たち、彼らの家族も配給を受けていた。数千人に及ぶ女官たちと多数の召使、王宮内と大奥の実務を担当する女官と下女たち、⑥王侯と地方長官、スロック（郡長）の長、プム（村）の長など数万人、⑦各地の寺院で下働きをする寺男・寺女たちの奴隷たち数千人、⑧さらにネアック・チカ（村人たち）の許で働く奴隷的身分の人たち、それぞれ家族があった。⑨親衛隊数百人以上、王直属の軍隊数万人、男奴隷は大砲手、火工兵、射撃兵、射手、女奴隷料理人、⑩各地方から出てきたカンボジア人村人とその集団、⑪中国人、チャム人、シャム人、モン人集団、山岳民族などが在住していた。碑文および中国史料で言及され、さらに浮彫り絵図に描かれた人たちも挙げられる。（参考文献：石澤良昭「アンコール王朝で働いていた役職高官たち」『カンボジアの文化復興』32 号（2021 年）pp.47-69）

フランスのフィガロ紙（2007 年 8 月 13 日付）は「ここには巨大な貯水池が 4 か所にあり、最盛期の人口が 100 万人を超えていた」と報じている。もちろん、同紙はフランス極東学院のこれまでの学術調査が言及し、B.Ph. グロリエが紹介されている。

(10) アンコール地方では中小河川の水と雨水を使っていた

推測すると、二毛作（三毛作？）となって、裏作に野菜あるいは米以外の穀物を作ったに違いない。アンコールの栄華はバライによる集約農業システムに移行してから大発展を遂げ、その王朝の栄華が達成されたのである。この貯水池（バライ）により、カンボジア人にとって国土が瘴癘（しょうれい）の地であるという負の自然環境を少しずつ克服していた。しかし、アンコール王朝は水を管理したことで、「経済的余剰」を生み出した。都城とその近隣に大人口の存続を可能としていた。その人的資源がもたらすものは、歴代の王の寺院建設熱に応え、いく

つもの大寺院建立ができたことである。

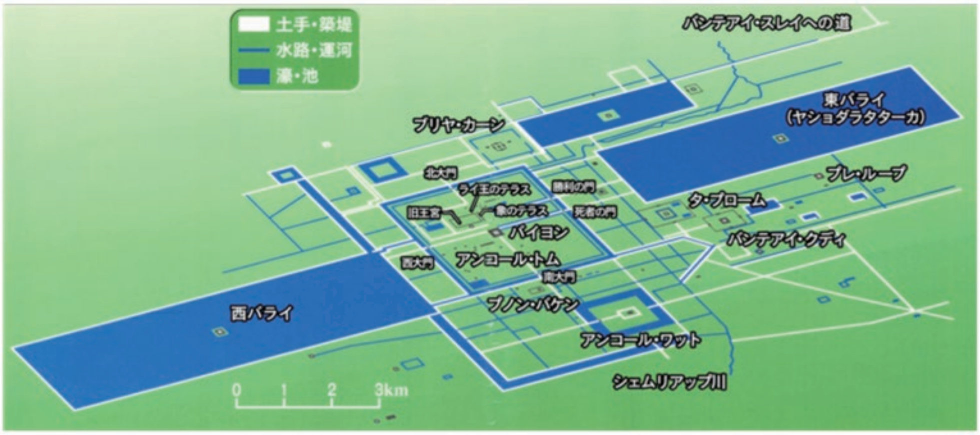
アンコール王朝の発展は、一言でいえば「水」の管理により方向づけられていた経済力であった。アンコール地域は相対的に乾燥した熱帯性気候であり、年降雨量は約1500ミリ内外である。そのため、「水」を貯えることは、この地域に住む人々にとって昔から生活の基本でもあった。すなわち、あまりにも短時間に過剰に降る雨水をどのように排水し、乾季に備えてどのように貯水していくかは、アンコール時代も現在と同様に居住するカンボジア人の課題であった。結論からいえば、当時のカンボジア人は中小河川の流水および雨水を自由に調節する困難な開発事業に成功し、それがアンコール朝の経済基盤を支え、人口が増え、大寺院がいくつも建立された。強力な王の下では治安が安定し、強力なシャムなどの外人象軍団により平和が続いた。

アンコールの大地は、数万年かかって形成されたプノン・クーレン山系から流れ来るシェムリアップ川の広大な扇状地であり、まったくと言っていいほど平板な地形である。田植えをするには、貯水池の水の厳密な管理が必要であった。

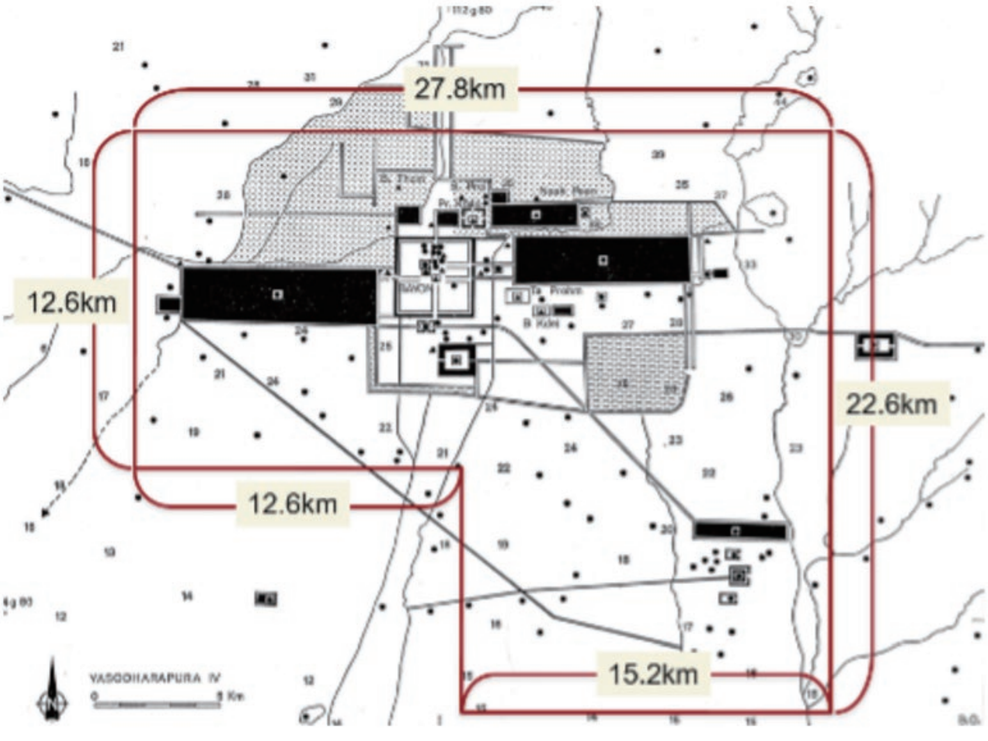
（11）アンコール王朝時代の大型バライ（貯水池）

名称	場所	建設年	長さ(m)	幅(m)
インドラタターカ	ロリュオス:アンコールから13km	880年	3800	800
東バライ	アンコール地方	890年	7000	1800
ラハール	コー・ケー:アンコールから 130km	935年	1200	560
ベン・メリア	ベン・メリア:アンコールから70km	1075年	1450	680
西バライ	アンコール地方	1020年	8000	2000
東南バライ(未完成)	アンコール地方	1120年	4000	3000
バライ・ベン・プリヤ・ストゥン	大プリヤ・カーン(コンポン・スヴァイ) :アンコールから150km	1170年	3000	750
バンテアイ・チュマール	アンコールから170km	1180年	1650	800
ジャヤタターカ	アンコール地方	1190年	3500	900

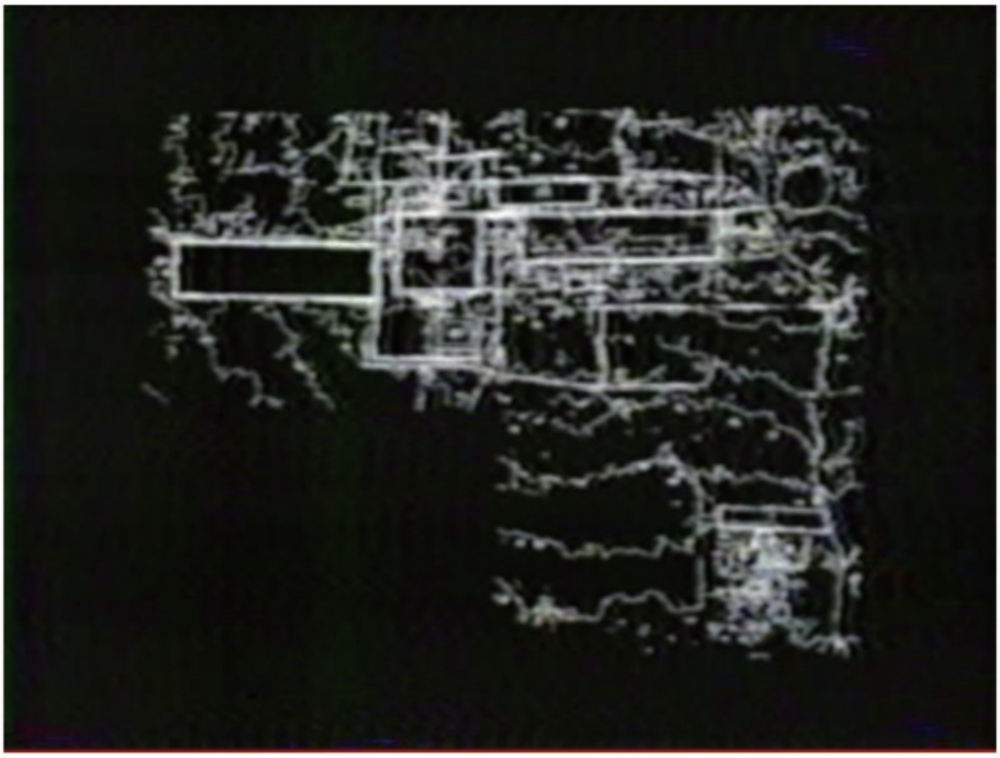
（12）コンピューター・グラフィックによる 900 年前の田越灌漑と畔道発見
ー JICA・NHK・上智大学ー



アンコール遺跡群地図

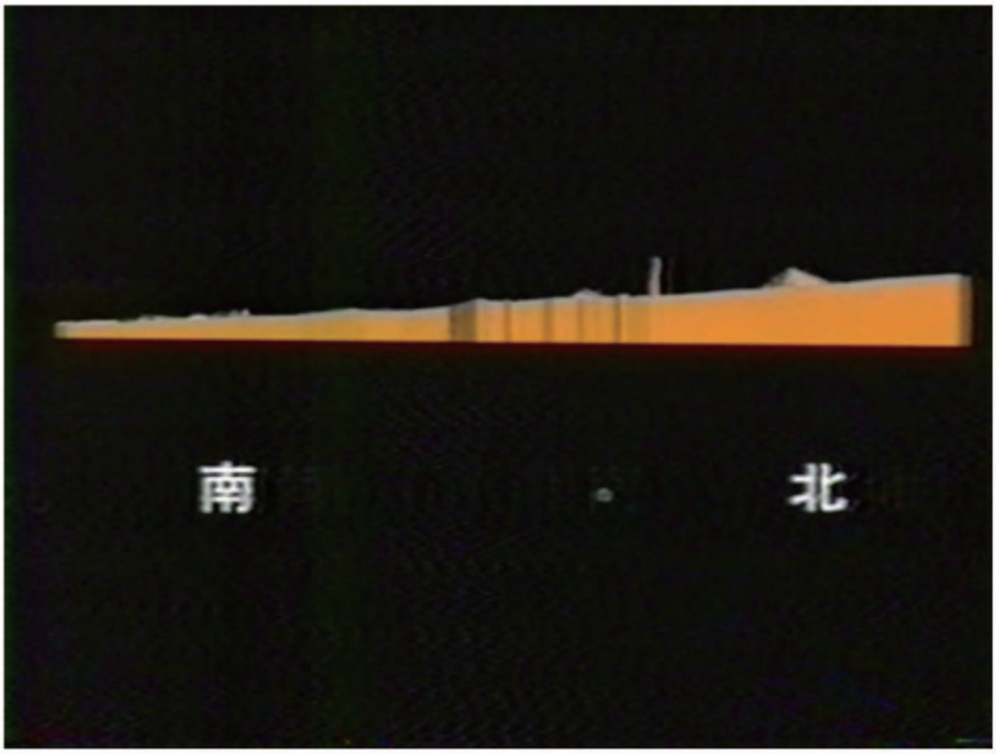


アンコール遺跡平面図（第 4 次ヤショダラプラ）（12 世紀）
La cité hydraulique Angkorienne 1979, p. 201

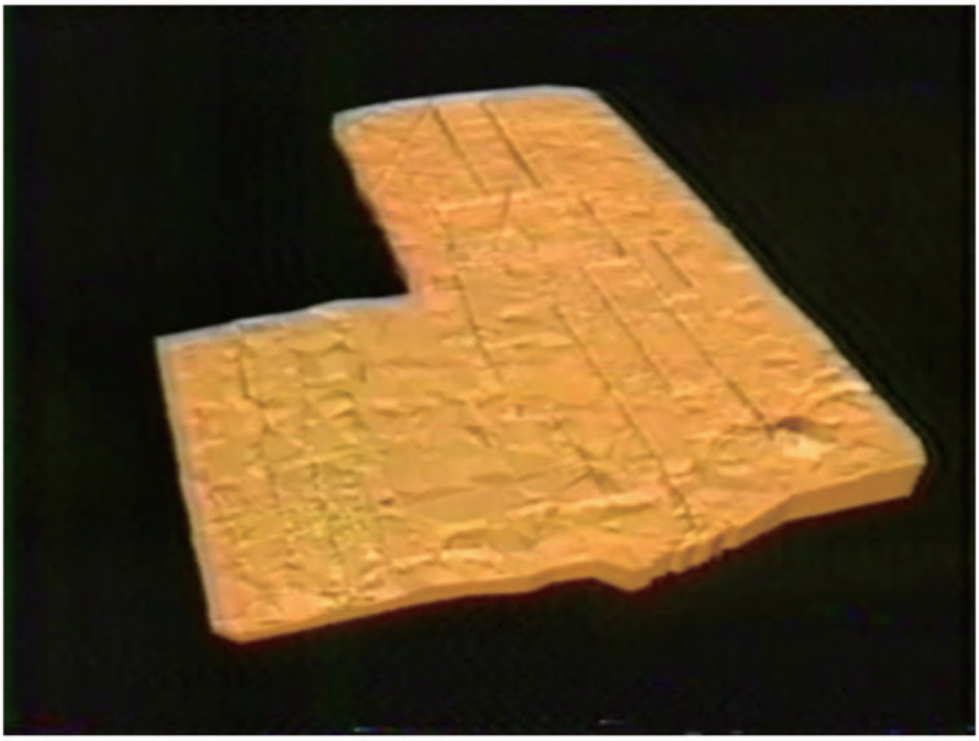


1/5000 の地形図 西バライ、アンコール・トム、東バライ、ハリハラーラヤを確認

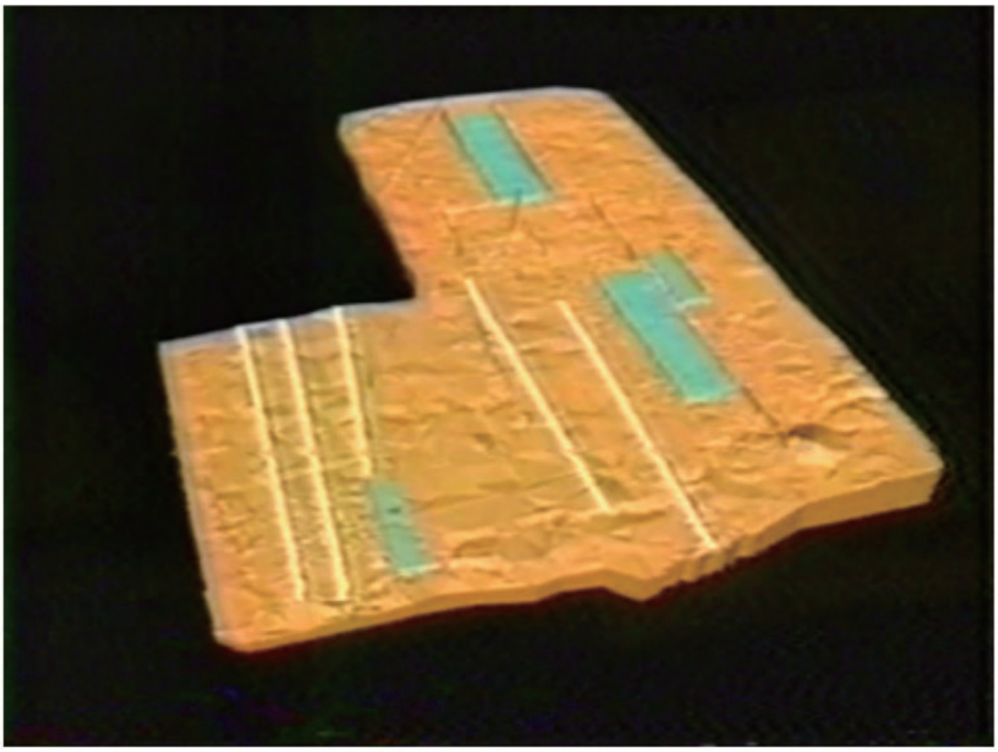
2 キロ× 8 キロの大貯水池（西バライ）11 世紀～ 13 世紀にかけて、乾季にこの雨水を使って 2 回目（3 回目）の耕作をする。アンコール都城の王をはじめとする高位高官、建寺作業員とその家族に食糧として供された。
（西バライ、11 世紀前半）



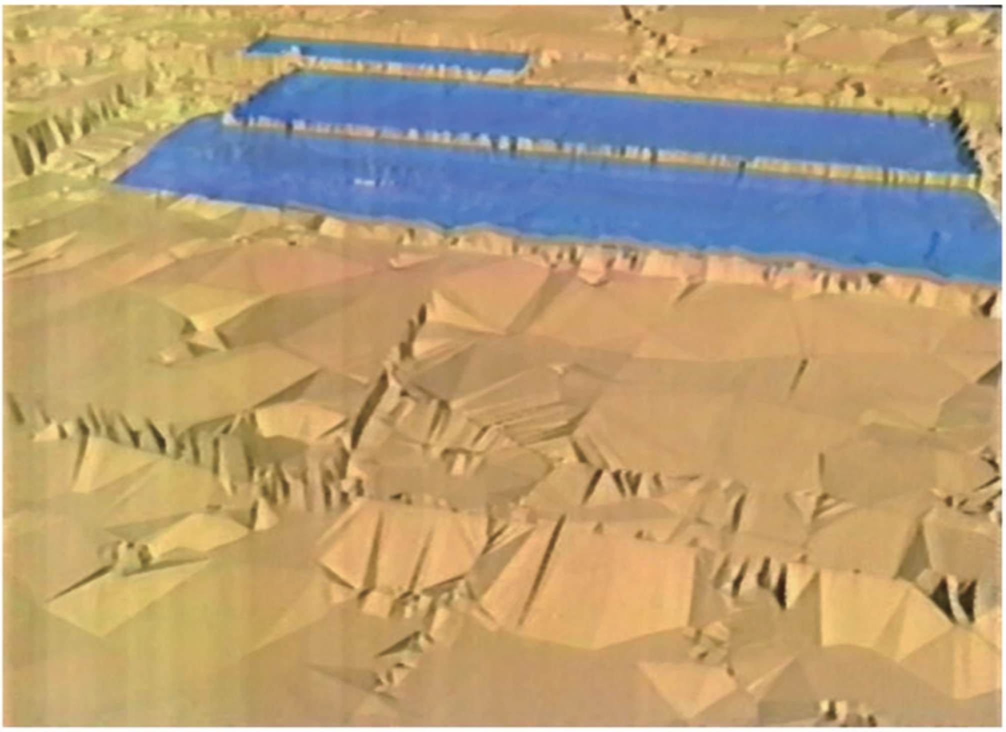
コンピューター・グラフィックを 40 倍に引伸す。
扇状地のアンコール地方、北から南に傾斜した地形断面図（1 ㎞で約 1m の落差）



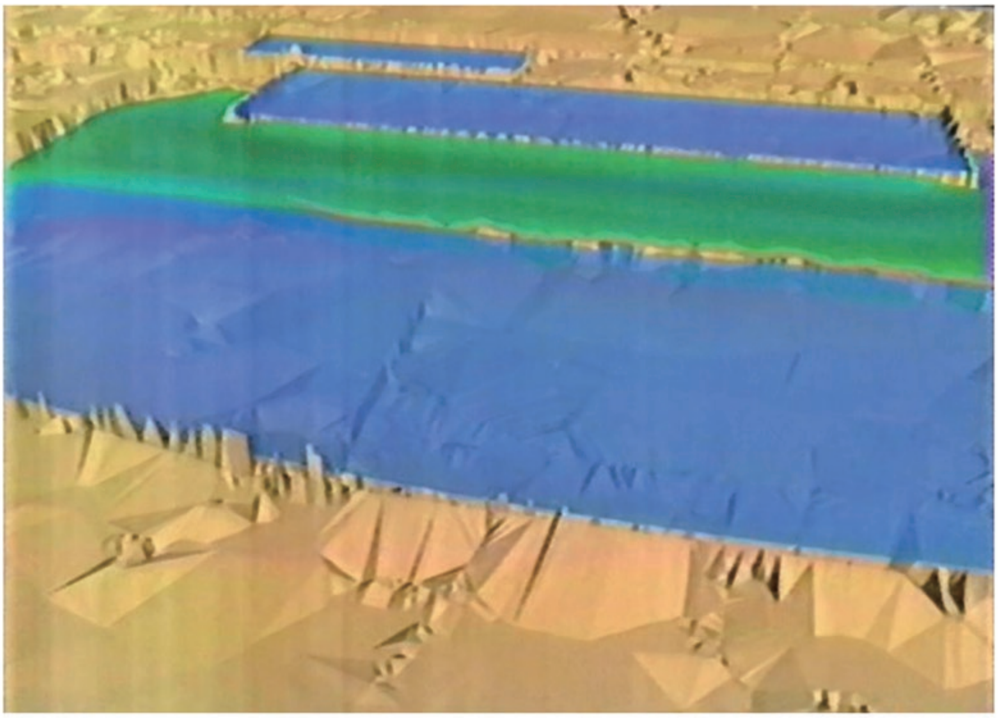
バライ（貯水池）下位の地形図、バライに平行した人工の盛土跡を発見



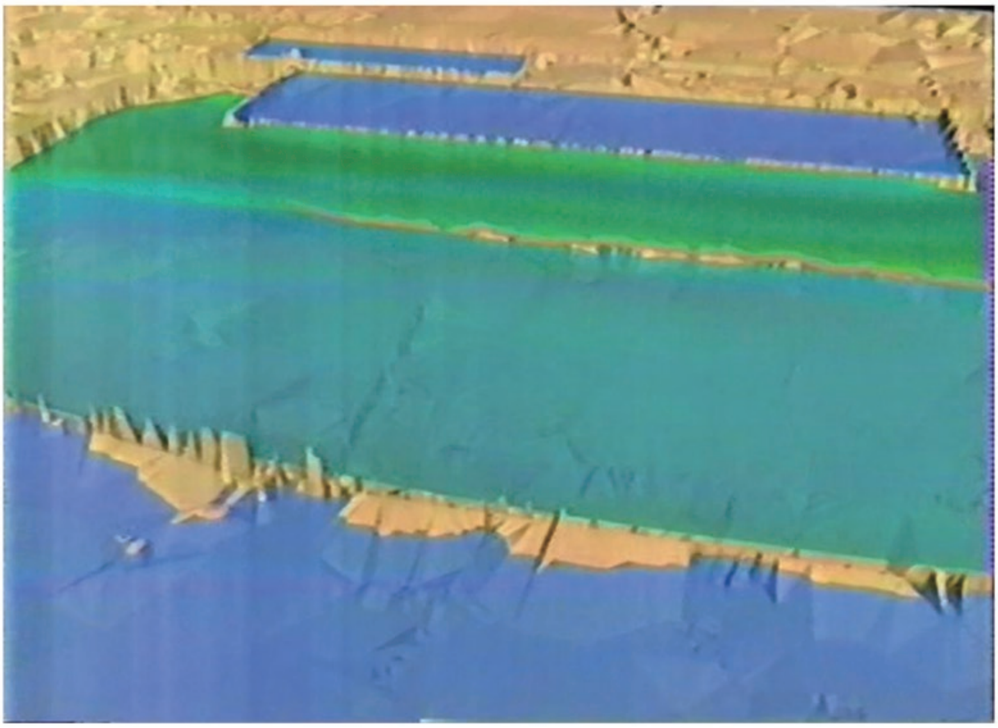
コンピューター・グラフィックによるバライ（貯水池）が４箇所見える。
バライの下位（南）に人工の盛土跡が平行して確認できる。



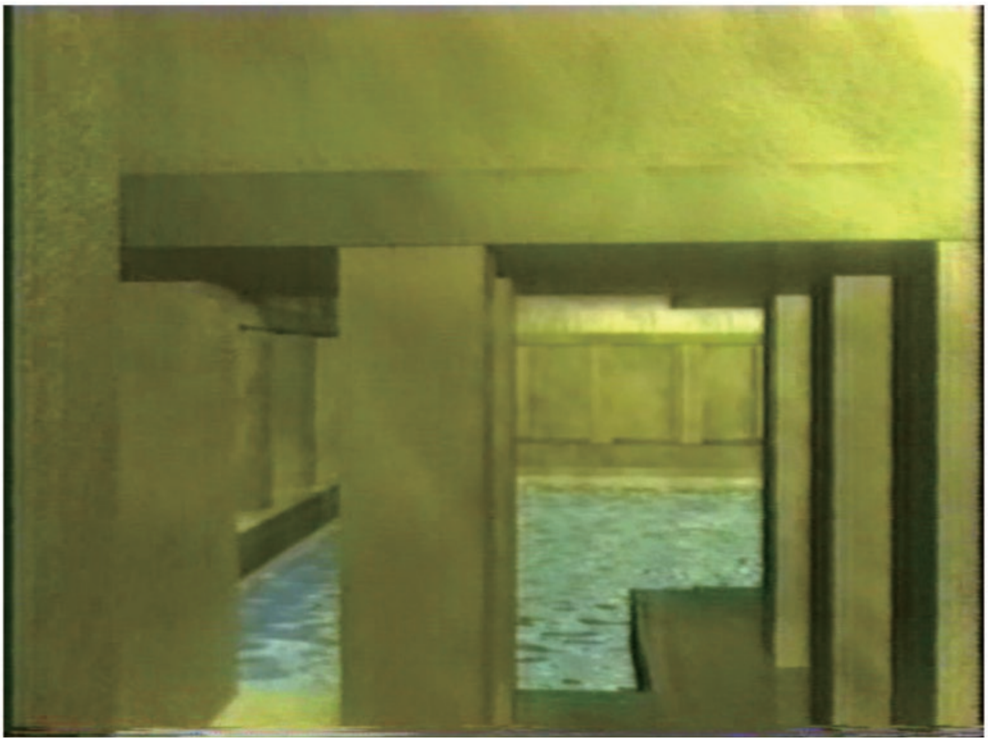
バライの下方に人工の小盛土（あぜ道）が平行している図面を確認、上位の田地に水を導水する。



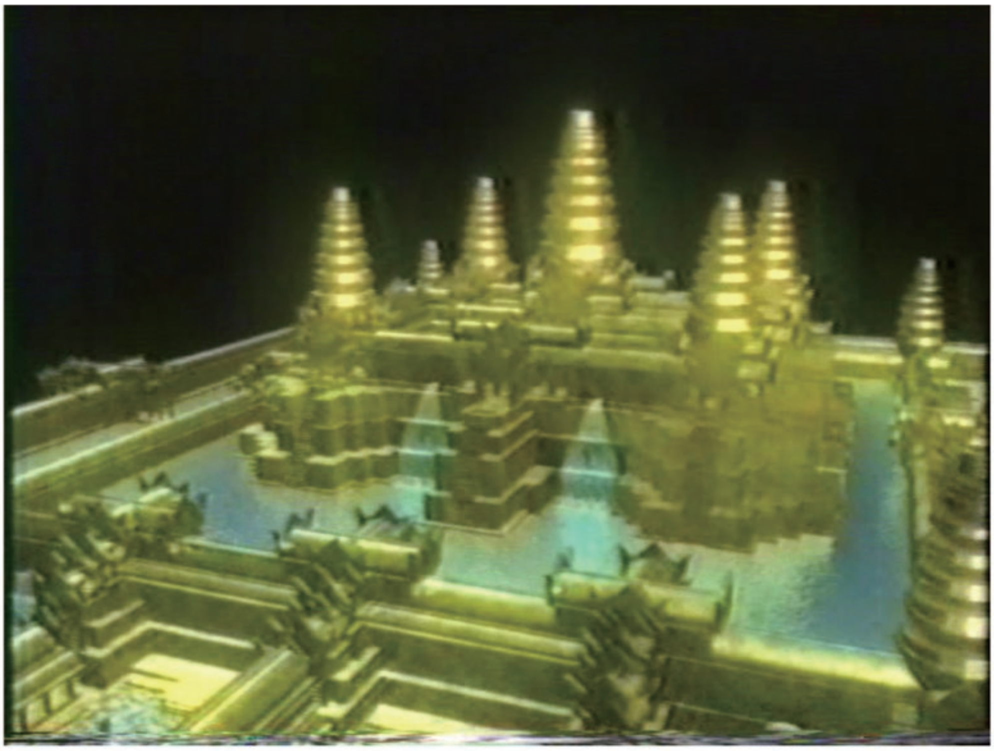
バライ（貯水池）の水が下位の大水田（田越し灌漑）に入り、
稲が根付いたところで、その水を再び下位へ流し、田植えをする。



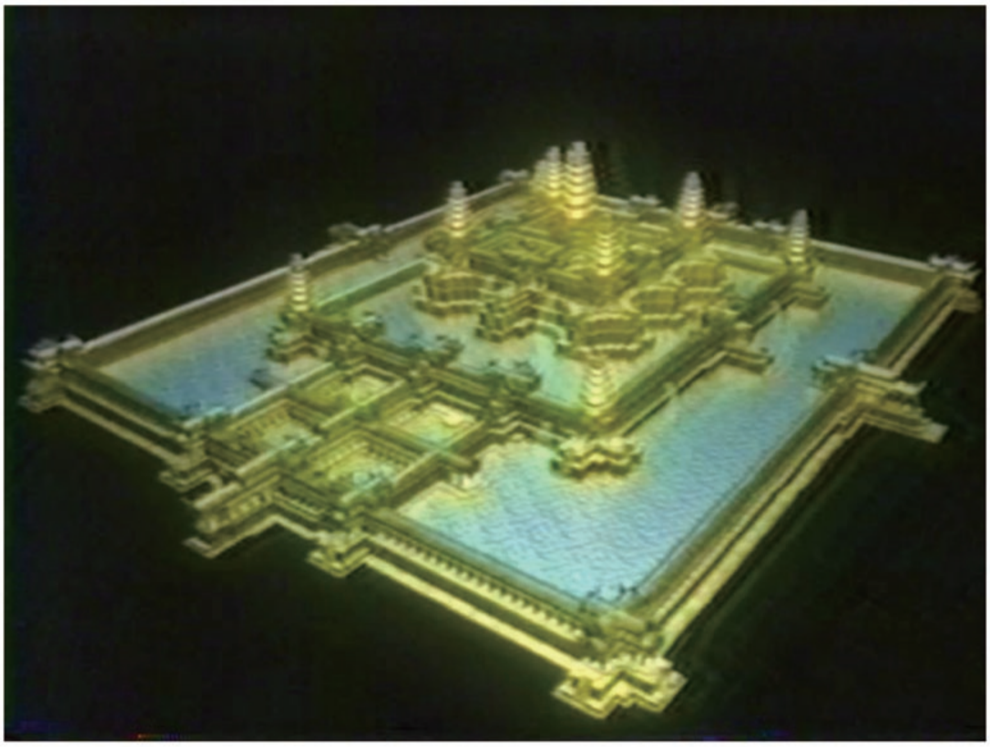
バライ（貯水池）の水が下位の大水田へ流し込まれ、二期作が可能な当時の現場であった。



アンコール・ワット寺院における「水の神ナーガ神」に捧げる祭儀式神々が棲むといわれる黄金の高塔（須弥山）を水面に写し、神々を称え、輪廻転生を演出した。



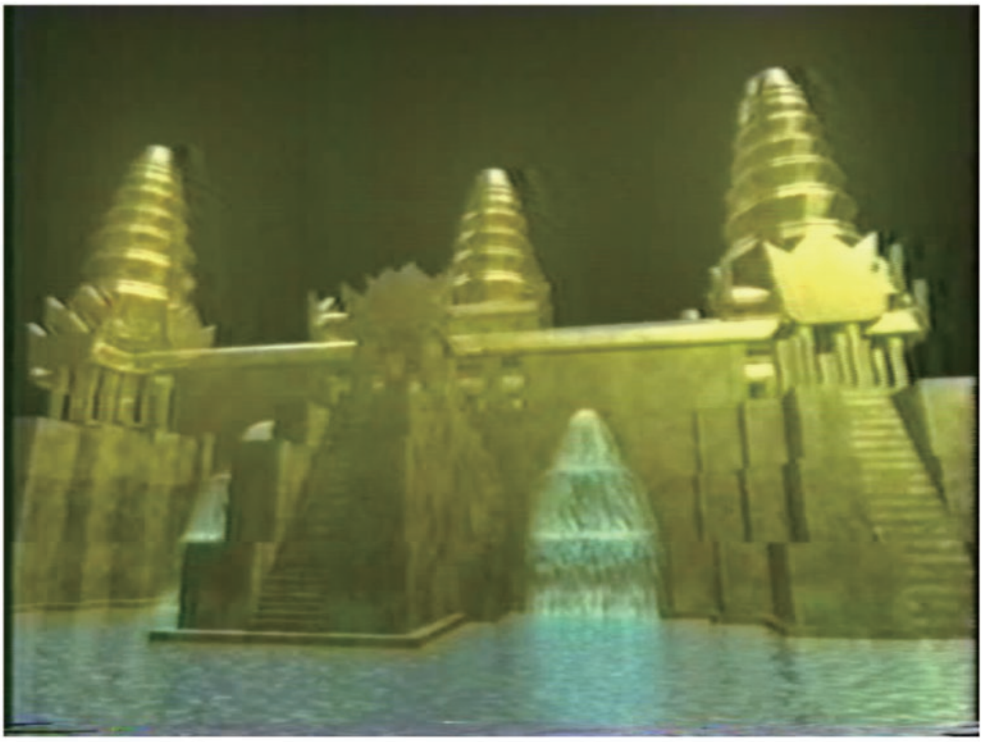
アンコール・ワット第３回廊の４池に溜まった神聖な水を、第２回廊に流し、さらに中回廊の４池へ落としていく。村人はその水を竹の筒に入れて薬草と共に飲む。



アンコール・ワット第１回廊には乳海攪拌の絵図があり、この絵図の前で神事が執り行われていた。

アンコール・ワット本殿の尖塔と大階段

アンコール・ワットの中枢部分である。第２回廊と本殿の間に内庭が見えるが、往時はうすく水をはった広い大きな池であったといわれ、大階段への通路が陸橋式になっている。急傾斜の大階段を登ると第３回廊、本殿へつながる。赤い夕陽に５基の高塔堂が照り輝き、内庭の壁面を埋めるデヴァター（女神）たち、柱の装飾文様、格子の円柱窓、大階段まで金色に輝きはじめて参詣者を崇高な世界に誘う。



アンコール・ワット内の貯水池において「水の神ナーガ」の乳海攪拌儀礼を実施

「乳海攪拌」の浮彫り アンコール・ワット第１回廊
ヒンドゥー神話「乳海攪拌」の場面が約50mにわたり回廊画面いっぱいに描かれている。大亀の背中に乗ったヴィシュヌ神、大蛇の胴体を綱にして、右側の神々88名と左側のアスラ（阿修羅）92名が妙薬アムリタ（甘露）を入手するために海中をかきまわしたという。力のはいった両脚と腕、絵画的にもすぐれた迫力のある躍動的な場面である。

アンコール・ワット十字型中回廊

第１回廊と第２回廊をつないでいる。この中回廊には約 12 メートル四方の池が四つあり、これはその一つである。当時、ここには聖水がたたえられ、参詣者は沐浴して身を清めた。回廊の屋根まで花弁文様や苦行僧などの精細な浮彫りが刻まれている。この回廊の柱には 14 カ所にわたり日本人による墨書跡があり、なかでも森本右近太夫の遺筆（寛永９年、1632 年）が有名である。

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“Discovery of Footpaths between Rice Fields for Tagoshi Irrigation from the Computer of the JICA (Japan International Cooperation Agency)”

Yoshiaki Ishizawa
Director, Sophia Asia Center for Research and Human Development
Sophia University

Today, our co-organizer Dr. Yoshiharu Tsuboi introduced Dr. B.P. Groslier to the audience, and following this Dr. Roland Fletcher, who is in charge of the NASA survey, flew in from Sydney. He is the professor who was concerned with the NASA survey of August 2007. Next, Dr. Dominique Soutif, a specialist in epigraph research from the École française d’Extrême Orient was present from Siem Reap, and thirdly I wish to thank His Excellency Dr. Hang Peou of the APSARA Authority. He was present despite his busy schedule of official duties, as Director General of the APSARA National Authority of the Royal Government of Cambodia. He is an expert in study concerning the Hydraulic City. Finally, we had an e-mail message from Dr. Christophe Pottier, Director of Research at the École française d’Extrême Orient. He came from Chiang Mai in Thailand.

1. Aerial Survey Topographic Maps offer Glimpses into a History almost 900 years old

The JICA (Japan International Cooperation Agency) 1:5000 topographic map of Angkor has offered us academic data to verify the concept of the Hydraulic City as proposed by B. P. Groslier, as well as the affluence of the Angkor dynasty through its intensive agricultural economy. It has also granted us academic data that back up the historical facts. Aside from rainwater, the Angkor region is fed by the Siem Reap River and other small and medium-sized rivers. This enabled the construction of two huge Barays (reservoirs) as well as other structures, which may be viewed today as relics of that period. At that time the Barays were used to irrigate several large paddy fields, and intensive agricultural production with two harvests a year was somehow practiced, for around 600 years.

From this JICA 1:5000 topographic map, we were able to confirm a great many historical facts, for instance concerning old roads, embankments, bridges, ruins of buildings, old riverbeds, and so on, all of which came to the fore. Historical facts revealed by topographic maps are concrete and persuasive. Large alluvial fans and Barays, fields, rivers, riverbeds, levees, bridges, traces of floods, small embankments, ridges, and so on, were captured across 800 years of time and space. By decoding the topographical map, we will be able to identify the remains of the infrastructure-related sites of the time, the remains of residences used in daily life in the villages, and the plots of rice fields. Through this symposium, we are able to provide an answer to the question as to what sort of economic activities gave rise to the success of the Angkor Dynasty. Despite the loss of Palm Leaf manuscripts that were used for the writing of “Dynastic Chronicles” and so on, a ray of light has been shed for us with regard to the history of around 800 years past, a period when historical details tend to become a mystery. However, it is regrettable that B.P. Groslier, the proponent of the theory of the “Hydraulic City,” has passed away.

2. 1:5000 Topographical Map Data – Micro-altitude Topographical Map Enlarged 40 times

The JICA implemented the Cambodian Agricultural Development Technical Assistance Project [Officially titled: Topographic Mapping Survey of the Siem Reap and Angkor Archaeological Park in the Kingdom of Cambodia (1994 –1998)]. This project was presented to the International Construction Technology Association and Kokusai Kogyo Corporation. Dr. Akira Goto, an expert on irrigation engineering and professor at the Faculty of Agriculture of Utsunomiya University played a key role as expert advisor, while Mr. Katsuhiro Inoue, an NHK director producing programs based on local images, and I, Ishizawa, who provided on-site information in the Angkor area, joined the project. Vast amounts of data were amassed, and when I saw parts of it while carrying out archaeological research in the field, I was amazed at the clarity of the data, such as the resolution. I had observed archaeological sites from the air on regular flights earlier, but this was the first time I saw a computer-generated topographic map before me. I recall having been astounded at seeing rice fields, roads, large and small rivers, and ponds clearly arising on the large fan-shaped area stretching from the Kulen mountain to the shores of the Tonle Sap Lake, along with larger and lesser ruins. This was right around the time I was preparing for a request from the NHK, to cooperate in creating a documentary on Angkor Wat. I promptly spoke to the individual in charge of the NHK (namely director Katsuhiro Inoue) concerning this JICA topographic map project, after which we reached an agreement and went to Cambodia, to record local data along with the NHK TV team. On November 16, 1997, the program was aired on NHK General TV as “Angkor Wat–The Unknown Empire of Water,” and it received great approval.

So how did the people of the Angkor period of that time utilize this hydraulic irrigation? On this 1:5000 topographic map, contour lines can be drawn at intervals of approximately 15 meters. On the basis of the data contained in this topographic map, we were able to explore the irrigation methods of the Angkor period by drawing a three-dimensional topographic map of the Angkor region, using computer graphics.

On converting the contour data of the topographic map into three-dimensional data for almost the entire area of the capital city, we found that the Angkor region has a plate-like topography with almost no ridges. However, in order to explore the traces of irrigation in the Angkor period, when the height difference of the micro-high topographic map was enlarged 40 times and reproduced, we could confirm the fact that thin lines and dots were lined up at almost the same intervals, parallel to the embankment of the reservoir. These were precisely traces of the old footpaths, that raised the ground artificially. Some of these man-made embankments were partially or largely washed out in later periods, and are therefore difficult to identify.

Horizontally, the topography of the Angkor area can be seen to slope slightly from north to south. Broadly speaking it is a large alluvial fan created by the Siem Reap River in the remote past, and its slope is about 1.5 kilometers horizontally, but the difference in elevation is just over one meter. The Cambodian people discovered this slight natural slope and used it to distribute water throughout the wide alluvial fan.

3. The Great "Tagoshi Irrigation" system came to be created

The scenario was perhaps somewhat like this. In the dry season, when the levee of the reservoir was cut (the levee has not been surveyed yet), the water flowed slowly along the slope. If the bank were to be cut further down, the water would fall to a lower level. A large section surrounded by banks was used as a single paddy field for planting, and when the rice took root, a minimum amount of water was left, and the water was drained to the paddy field in the next lower enclosure. This is what is referred to as the great "Tagoshi Irrigation."

This is at most a hypothesis, but we may assume the Cambodian people of that time successfully overcame the adverse conditions of dry and cracked rice fields during the dry season, by developing their own unique irrigation methods that were unprecedented in the world. During the time of the Angkor Dynasty, the villagers cut the embankments of the reservoirs under the direction of the king and began planting rice all at once over several kilometers of paddy fields. After the first rice field was planted the remaining water was poured into the lower large paddy, and the planting of the next paddy field commenced. In this way, large paddy fields were created. The next step was harvesting. If repeated twice a year this rice planting and harvesting brought great progress to the Angkor Dynasty, and the steady increase in food production led to population growth. For example, temple construction workers and their families gathered from various areas near the Angkor capital, traveling on foot or by oxcarts. The arrival of the Cambodian villagers to the temple construction site was a service tax (rājakārya) to the king, and it is surmised that another possible reason may be the fact that "rice" was available for them to eat. In Cambodia, the temperature is usually around 27 degrees Celsius in the cooler Spring months, and the people built huts near the temples they erected and used them as their residences. Although the work was hard, the fact that adequate food was provided was probably the most alluring feature of the work. It is believed that those who gathered for work were not merely local people who had heard the rumors, but also those who lived in distant places, such as the Khmer, Siamese, Cham, Hmong, Burmese, Chinese, Lao, and those belonging to hill tribes. For the Cambodian people participating in the construction of temples was an issue linked to spiritual merit and a ticket to Paradise.

The reason why the king chose the large alluvial fan stretching from the Kulen mountain to the shores of Tonle Sap Lake as the foundation site of the kingdom, is believed to be the availability of water. It was a vast Angkor alluvial fan that was always fed by the Siem Reap

River, from the Kulen mountain range.

4. The NASA International Research Team Proves the Existence of the "Hydraulic City"

Later in August 2007, a NASA international research team led by Dr. Roland Fletcher arrived in Angkor, to conduct a hydrological survey. Using image analysis equipment having a resolution of less than one meter and a high-resolution radar, they confirmed and publicized the remains of water facilities and waterways on-site, from the Angkor Dynasty (9th to 15th century). That is to say, it was an all-inclusive survey of the topography of Baray locations, Barays, traces of waterways, and traces of rice paddies. As an upshot of this, we grew aware of the historical fact that a large-scale waterway of 1,000 kilometers, was once operating in the Angkor Capital City. The water intake and drainage outlets of the Barays were reconfirmed, and what was also confirmed was the fact that water flowed from the channels to rice fields in the adjoining areas. A hypothesis was also proposed that the population at its peak may have exceeded a million, and we also confirmed the fact that the development of this Hydraulic City was an operation conducted under the zealous will of the king.

The report of the international research team from NASA and the École française d'Extrême Orient was recounted in full in the French newspaper Le Figaro (August 13, 2007) under the heading, "Utilization of Large-scale Hydraulic Facilities in the Angkor Capital City." Also, the aforesaid NASA survey results were featured in the National Geographic, (Japanese version, Vol. 15, No. 7, July 2009). On the basis of interviews with two experts who joined in the research, the magazine presented the photographic data of the research entitled, "The Rise and Fall of the Angkor Dynasty," along with photographs of remnants of the capital city ruled by water. The remains of waterways distributing water to the rice paddies were confirmed, and the total population of the area was said to have been around 750,000. It is said that 200,000 civil workers were mobilized for the embankment of the Western Baray (2 km x 8 km), and this was also an argument in support of the Hydraulic City theory of Dr. Groslier.

5. Angkor Wat, a Silent Messenger whose Speech Transcends Time and Space

Angkor Wat, a colossal stone temple that envisioned the profound beliefs of the period, is a temple that was viewed as being of peak value by the Cambodians of that time, and its spatial shape has been said to resemble the Pure Land of Paradise. Against the setting of the jungle in the vicinity, the golden spires shine out brightly, overwhelming visitors and villagers alike. If I were to describe my own feelings, I may perhaps say that I was so moved, that I was assured paradise must exist beyond the sky of Angkor Wat. The 5 great spires of Angkor Wat, the 200-meter wide moat, the three-story Grand Corridor, the staircase that seems to reach the sky, and the 65-meter high spire were so moving, that all who observed them would not believe that they were of this world. They were imbued with a sense of realism that made people forget where they were at the moment. Those spires were adapted into a Cambodian style, from the cosmology received from

India. It was a new cosmic world conceived by the Cambodians, a celestial tower they themselves had created.

I would now like to mull over this from the standpoint of irrigation, as well as the wealth and infrastructure of the dynasties of that time. The water system of the grand moat of Angkor Wat served as a pond for water to be stored, due to the nation's weather conditions of rainy and dry seasons. There existed a reservoir (Baray) and a functioning irrigation system. After the rainy season had persisted for approximately 6 months, during the dry season the second crop of rice was planted employing the Tagoshi irrigation system. This irrigation system led to a steep rise in agricultural production, making it possible for a large populace to survive, and this in turn led to a policy of enriching the nation and fortifying the military. This enormous temple was visited by scores of villagers at that time, and the villagers received feedback in the form of an increase in their religious devotion.

6. Angkor, the Golden Capital City that unfolds in a Large Alluvial Fan

The paper of B. P. Groslier was published in 1979 in the Bulletin de l'École française d'Extrême Orient (BEFEO), and it has since been the target of a great deal of debate regarding its pros and cons. It was a crucial paper that backed the "economic activities" behind the great success of the Angkor Dynasty. If we were to graphically elucidate the economic setting around the year 1113 when Suryavarman II ascended the throne, we may perhaps hypothesize it thus: "reservoir (Baray) ⇨double cropping ⇨securing of food ⇨population increase ⇨decision with regard to the temple site ⇨securing of workers ⇨commencement of the construction." The alluvial fan which was the grand stage of the dynasty, sloped from north-northeast to south-southwest. It descended roughly 1.5 meters after about each kilometer, and below it were many fields that could be cultivated. This was the origin of the intensive agriculture of the Angkor Dynasty. A reservoir (Baray) was created in the upper region of the alluvial fan by constructing an embankment wall, rain and river water were drawn into it, and small furrows were made within and outside the Baray, to be used as secondary channels. Water was supplied to the paddy fields through a waterway from the outlet. It took 37 years for the king to erect the grand temple of Angkor Wat, yet certain parts are incomplete. The foundation is 187 meters by 215 meters, and the five spires in the center are 65 meters high (equivalent to a nine-story building today). Besides, the moat is 200 meters wide, with a circumference of 5.5 kilometers. It is surrounded by an 18-tiered paving stone wall, and holds approximately 5 million cubic meters of water. It was a massive construction project that took 37 years.

Basing ourselves on B. P. Groslier's research report and utilizing the 1:5000 topographic map data created by the JICA, we intend hereafter to substantiate the theory of the Hydraulic City of Groslier. The first "International Symposium on the Hydraulic City" was held in 2000, and this happens to be the second. Accepting the historical limitations pointed out by Cœdès in 1965 in his theory regarding historical inscriptions, and basing ourselves on the outcome of the in-depth scientific field research conducted by NASA and the École française d'Extrême Orient, we shall debate the theory of the Hydraulic City in this second symposium. It was the ethnic energy and wisdom of the Khmer people of that era, that empowered them to construct that mammoth stone temple.

7. A Case of Unhulled Rice Distribution: A Reconsideration of the Preah Khan Inscription of the 13th Century (K. 908)

The inscription records that unhulled rice was offered to priests of the Preah Khan temple, as well as to the men and women working in the temple. The unit used to deal with the rice is specified by the Sanskrit word "khāri," which indicates the weight of the unhulled rice. As it turns out, one khāri is nearly 96 kilograms. There is a record stating that at the Preah Khan temple, rice and food were issued to the men and women who worked in the temple precincts. (1) "The amount of unhulled rice that is distributed free of charge to the servants (temple men and temple women) of high priests and apprentice priests, is 22 khāri." (Inscription L Ⅱ). On conversion, it works out to 2112 kilograms of unhulled rice. That is, 35 bags of rice were received. A number of other examples of distribution are also provided.

8. Who was eating the Unhulled Rice of the Baray (Reservoir)?

It is believed that the majority of the temple workers were perhaps the tens of thousands of Cambodian peasants, who rallied during the dry season to work as a payment of a service tax (rājakārya) to the king. There were also many Siamese, Cham, Hmong, and mountain minorities at the construction site, but there were possibly some deserters among them as well.

Thousands or even tens of thousands of foreign temple construction workers were constantly being recruited, and large temples were being successively erected in the Angkor region. There were also many Siamese who returned or escaped from their migrant work in the Angkor region. Among them, influential persons advised the leading local people and other potent locals, to erect temples so as to gain merit. They would describe their experiences of erecting temples in Angkor, and assist in the building local temples and shrines. Hence, stone temples and shrines influenced by the architectural style of Angkor were constructed in Sukhothai, Ayutthaya, and Lopburi along the Chao Phraya River, in Prasat Muang Sing in southern Thailand on the Malay Peninsula, and My Son (southern Vietnam) in the Champa Kingdom on the South China Sea.

Judging by the calculations of B. P. Groslier, the first reservoir was in fact built in the latter half of the 9^{th} century, at the capital city of Hariharalaya. It was encircled by an earthen embankment on level ground, and it stored water. In the early 10^{th} century the Eastern Baray Reservoir (Yaśodharataṭāka) was constructed, and in the 11^{th} century, an even larger Western Baray was built. This Western Baray had a water storage capacity of 42 million to 70 million cubic meters and is said to have been able to irrigate 1,400ha of rice paddies. Eventually, it is said that in its heyday, the irrigation network that stretched across the Angkor metropolitan area was irrigating 70,000ha. Nevertheless, though, detailed historical material concerning the Barays of those times is lacking, and besides, we have no idea as to exactly how much rice was produced by developing those waterway networks. Records as to who benefited from that unhulled rice and who ate it have vanished, and all that remains with us is silence. Hence, I would like to study and learn from the inscriptions as to what sort of people received those rations of unhulled rice.

Hypothetically speaking, who were those who consumed the unhulled rice of the double-cropping intensive farming by use of the Baray? And who were those who received the rations? These are issues I wish to ponder over, and I shall specifically list them from the historical inscriptional material.

(A) They were the officials and dignitaries listed in the inscriptions and their families and servants, (even those with the status of slaves). They were individuals with titles and ranks. Moreover, they were religious officials and their families, as well as lower-ranking officials and their servants (persons with the status of slaves).

(B) They were special workers at the site who were linked to the construction of the temple, such as quarry workers including stonemasons, stone processing technicians, and temple construction workers, and their total number is estimated to have ranged from thousands to tens of thousands.

9. Is the Inscription a Record of those who received the Provision of Unhulled Rice?

Who were the recipients of those food supplies? I would like to itemize them as members of the dynasties cited in historical inscriptions and historical Chinese texts, as well as people inscribed in the reliefs as beneficiaries. For instance, wall reliefs from the ruins present large royal legions marching with tamed elephants. What manner of people were those who lived in the Angkor Capital City and its environs at that time? Historical materials of that time were written on Palm leaves, but they have disappeared. On choosing some fragmentary historical material from among the inscriptions (around 1,200 items), wherein people of that time are referred to, the following individuals emerge.

People at the very least wish to know how those who were said to have gotten daily rice rations in that era, were classed. In the capital city and its locale, (1) There were 100,000 members of the standing army under the direct control of the dynasty, tens of thousands of Siamese (Thai) mercenaries called Shams, and tens of thousands of Cham volunteer soldiers and other foreign soldiers, as depicted in the embossed corridors. (2) There were hundreds of architects who acted on the king’s zeal to erect temples. There were thousands of lesser workers and tens of thousands of civil engineering and temple erection workers from various places, a professional body of 200,000 artisans, masons, stone installers, stonemasons and so on, plus thousands of masons working in several sandstone and laterite quarries. (3) There was the king and members of the royal family, princes, the king’s younger brothers, the retired king and his relatives, the queen mother and her family, and families of her servants. Besides, there were thousands of others, including original vassals, royal family members, minor officials and servants who assisted them, and relatives of the royal family. (4) There were high-ranking officials who served in the royal palace, over hundreds of high-ranking officials with titles, chief attendants, high-ranking officials of the four royal families (such as the prime minister, minister of justice, minister of the royal palace, minister of the navy, minister of the army, and so on), many subordinates, errand-running servants, vast numbers of officials to carry out local services, and their subordinates. (5) There were former queens, princes, princesses, maids-in-waiting, court ladies-in-waiting, concubines of the king, their children, and their families who also received the rations, and thousands of ladies, several servants, ladies-in-waiting, and servants in charge of practical affairs in the royal court and in the inner palace. (6) There were tens of thousands of individuals including royal princes and provincial chiefs, heads of Srok (district chiefs), and heads of Phum (village chiefs). (7) There were thousands of male and female slaves working at temples in various places. (8) Also, there were individuals of slave status who worked for the neak chamka (farmers), all of whom had families. (9) There were hundreds of bodyguards, tens of thousands of soldiers under direct orders of the king, and male slaves who worked as cannoneers, pyrotechnicians, marksmen, archers, and female slave cooks. (10) There were Cambodian villagers and their groups from various regions. (11) There were Chinese, Cham, Siamese, Hmong groups, hill tribes, and other residents. We may also include those mentioned in inscriptions and Chinese sources, and those depicted in the reliefs. [(Reference: Yoshiaki Ishizawa, "High Officials Who Worked in the Angkor Dynasty," Renaissance Culturelle du Cambodge, No. 32, (2021), pp. 47-69).]

The French newspaper Le Figaro (August 13, 2007) stated, "There were four huge reservoirs here, and the population at its peak exceeded a million. Of course, the paper refers to earlier academic research of the École française d'Extrême Orient and introduces B. Ph. Groslier.

10. In the Angkor Region, Water from Small and Medium-sized Rivers and Rainwater was used

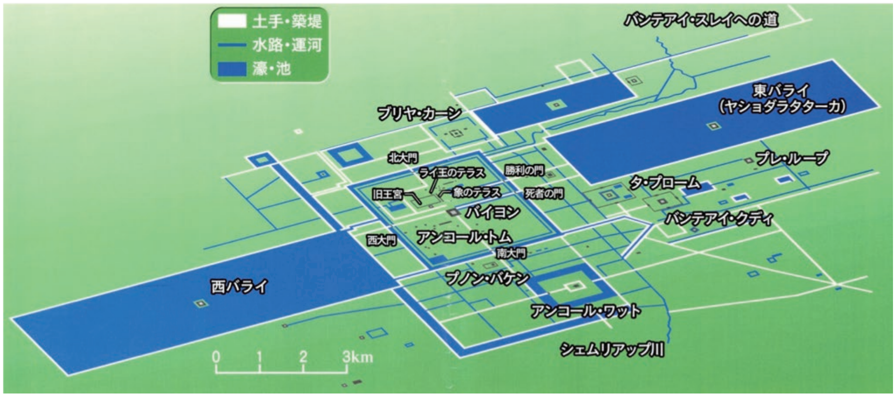
My speculation is there existed double crops (or triple crops?), and they may also perhaps have cultivated vegetables or grains other than rice, as secondary crops. The opulence of Angkor was earned after shifting to a system of intensive agriculture, by utilizing the Barays. This led to great expansion and the attaining of success by the dynasty. By means of these reservoirs (Barays), the Cambodian people steadily overcame the negative aspects of the natural milieu of their country, as a land of tropical diseases. However, the control the Angkor dynasty had over water also gave birth to an "economic surplus." It enabled the upkeep of a large populace within the Capital City and its vicinity, and what these human resources engendered was the raising of numerous temples, an urge stimulated by the zeal of successive kings to erect them.

In brief, the development of the Angkor Dynasty as an economic power was oriented by the supervision of "water." The Angkor region has a fairly dry tropical climate with an annual rainfall of around 1500 mm, and hence, storing "water" has long been the basis of life for people residing in this area. In other words, the draining of rainwater that falls within a very brief space of time, and the storing of water in preparation for the dry season, were issues the Cambodians in the days of Angkor had to grapple with, just as it is for the Cambodians of today. To conclude, we may say that the Cambodians of that time succeeded in an arduous development project, to freely regulate the flow of the small and medium-sized rivers and rainwater. This sustained the economic base of the Angkor Dynasty, boosted the population, and led to the construction of a number of mammoth temples. Security was stabilized under stalwart kings, and peace was upheld by mighty Siamese and other foreign elephant armies.

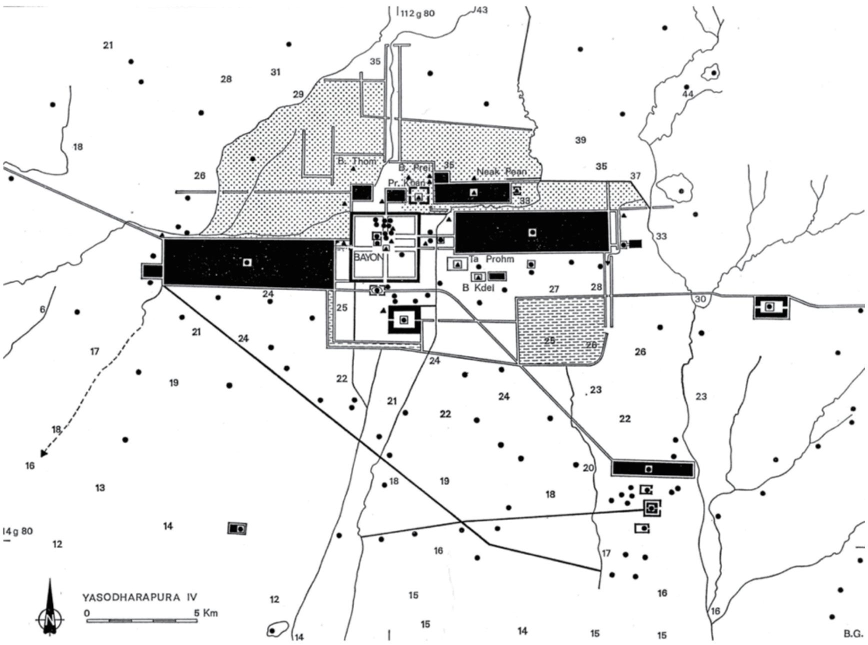
The land of Angkor is a vast alluvial fan of the Siem Reap River. It flows from the Kulen mountain range which took tens of thousands of years to form, and the terrain is entirely flat. Careful management of the reservoir water was crucial for the planting of rice.

11. Large-Scale Barays (Reservoirs) of the Angkor Period

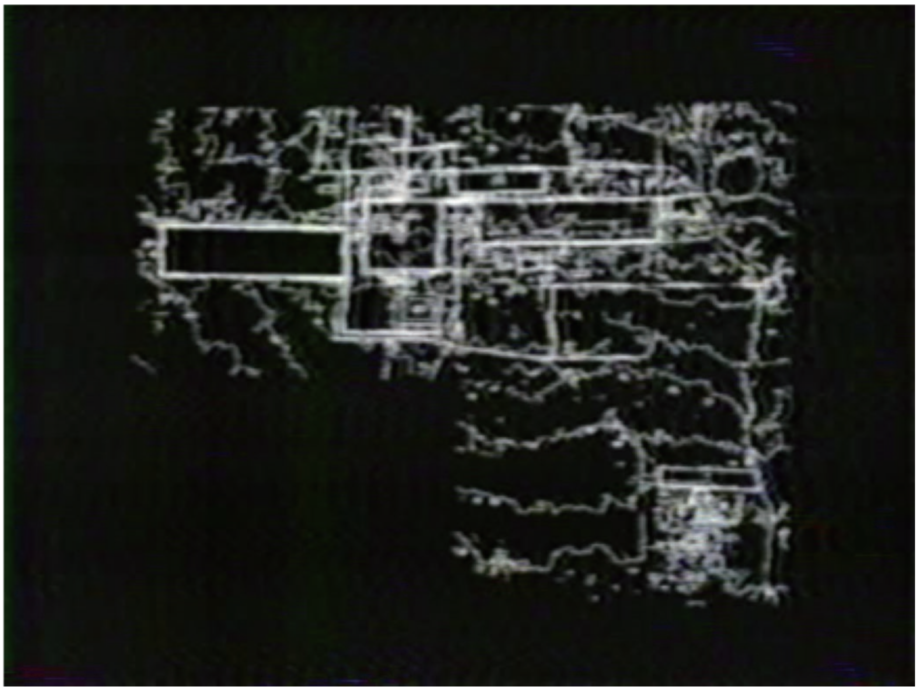
NAME	PLACE	YEAR OF CONSTRUCTION	LENGTH (m)	WIDTH (m)
Indratataka	Roluos: 13kms from Angkor	880 AD	3800	800
Eastern Baray	Angkor Area	890 AD	7000	1800
Rahal	Koh Ker: 130kms from Angkor	935 AD	1200	560
Beng Mealea	Beng Mealea: 70kms from Angkor	1075 AD	1450	680
Western Baray	Angkor Area	1020 AD	8000	2000
Southeast Baray. (Incomplete)	Angkor Area	1120 AD	4000	3000
Baray Beng Preah Stoeng	Great Preah Khan (Kampong Svay): 150kms from Angkor	1170 AD	3000	750
Banteay Chhmar	170kms from Angkor	1180 AD	1650	800
Jayatataka	Angkor Area	1190 AD	3500	900



Group of Angkor Monuments

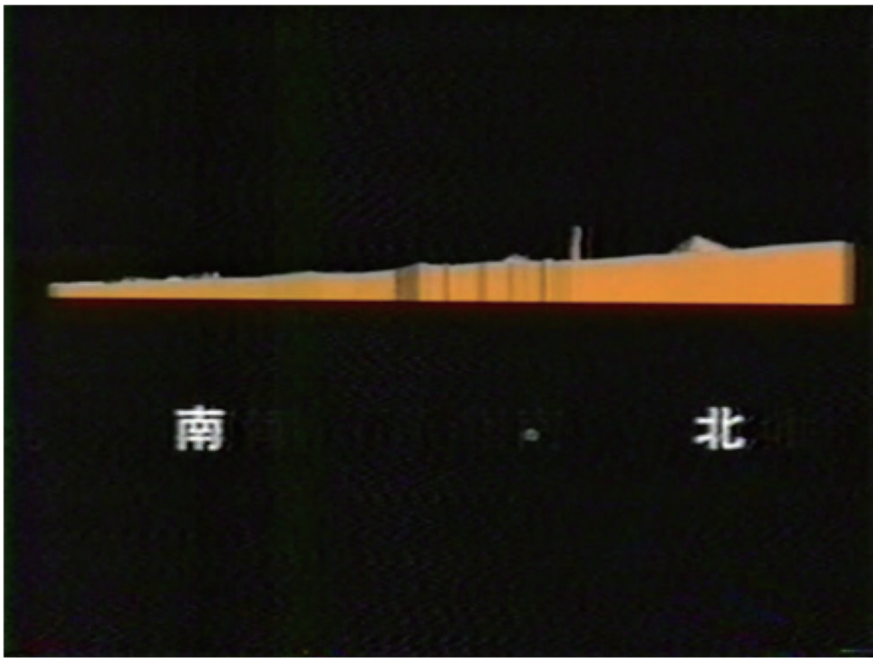


Map of Angkor Monument (Yośodharapura IV)
@ La cité hydraulique Angkorienne 1979, p. 201.

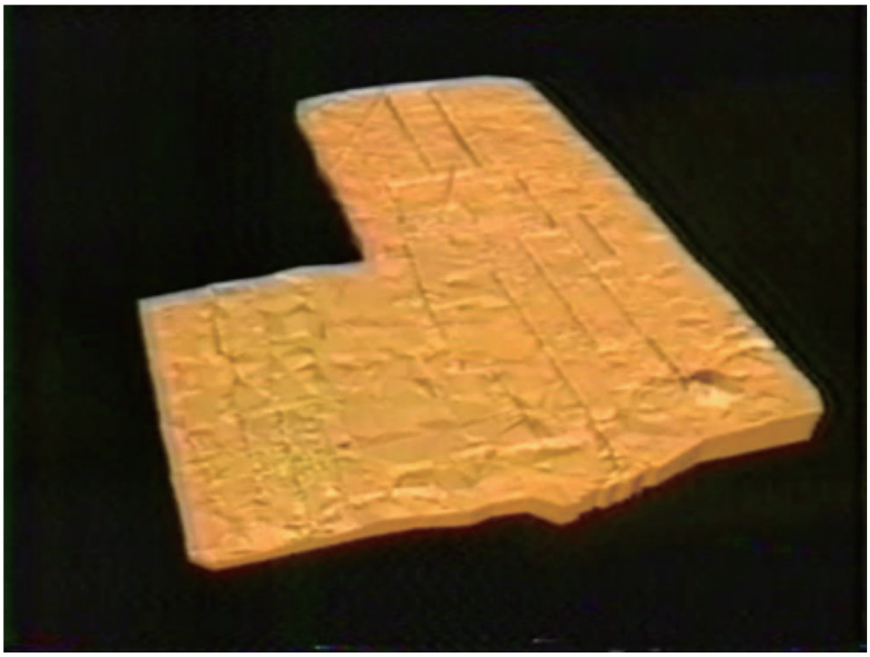


1/5000 Scale Topographic Map confirming the West Baray, Angkor Thom,
Eastern Baray, and Hariharalaya

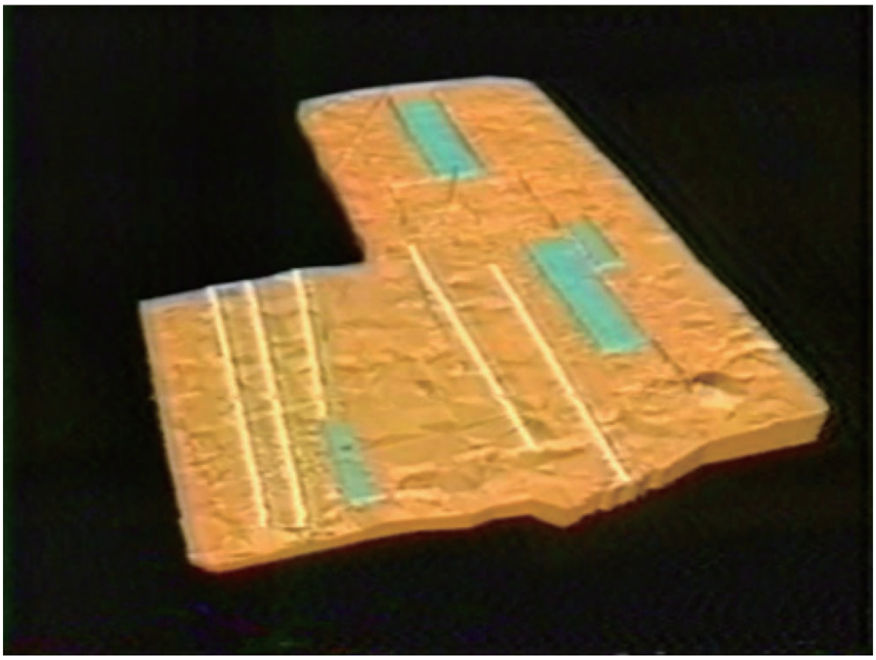
A large reservoir (West Baray) of dimensions 2kms by 8kms from the 11th to 13th century.
Rainwater was used during the dry season for a second (or third) crop. Starting with the king of Angkor capital city, it provided food to high-ranking officials, construction workers, and their families (Western Baray, first half of the 11th century).



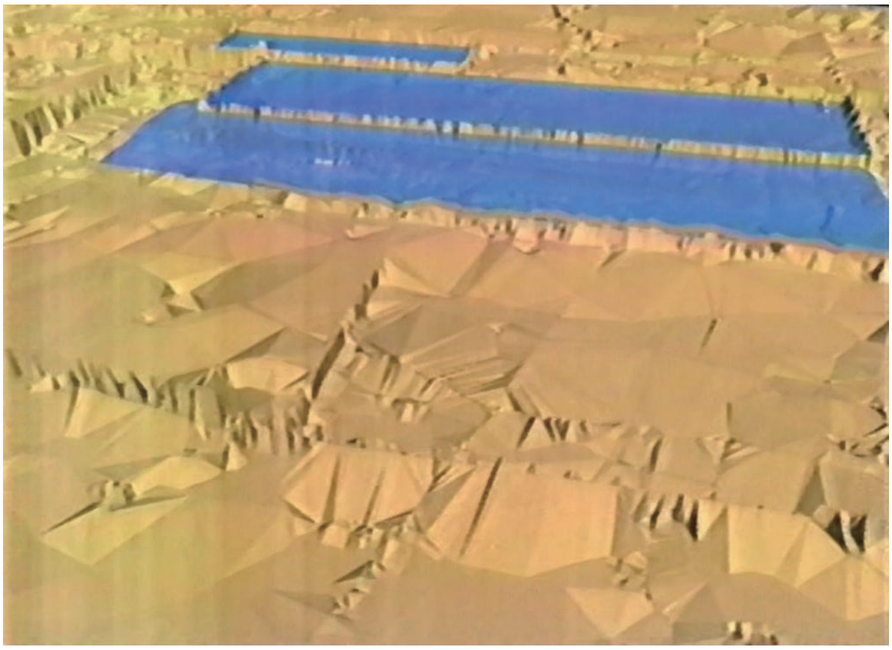
Computer Graphics enlarged 40 times
The Angkor area of the alluvial fan. The topographical cross-section slopes from north to south (with a drop of about 1 meter per kilometer).



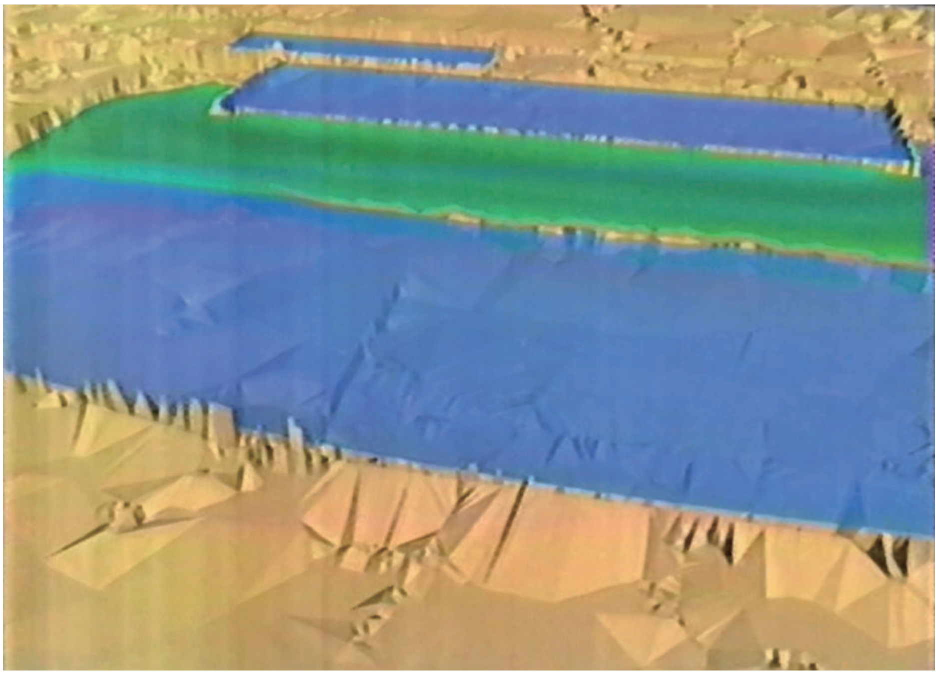
Topographical map of the lower area of the Baray.
Artificial embankment traces were discovered parallel to the Baray.



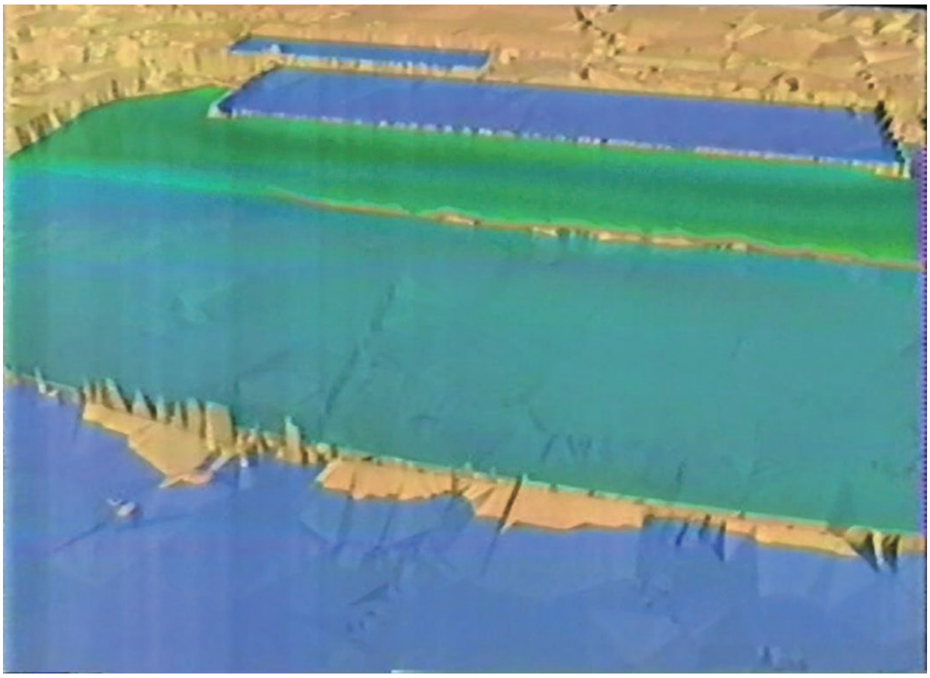
Four Barays are visible in the computer graphics.
Artificial embankment traces can be seen parallel to the bottom (south) of the Barays.



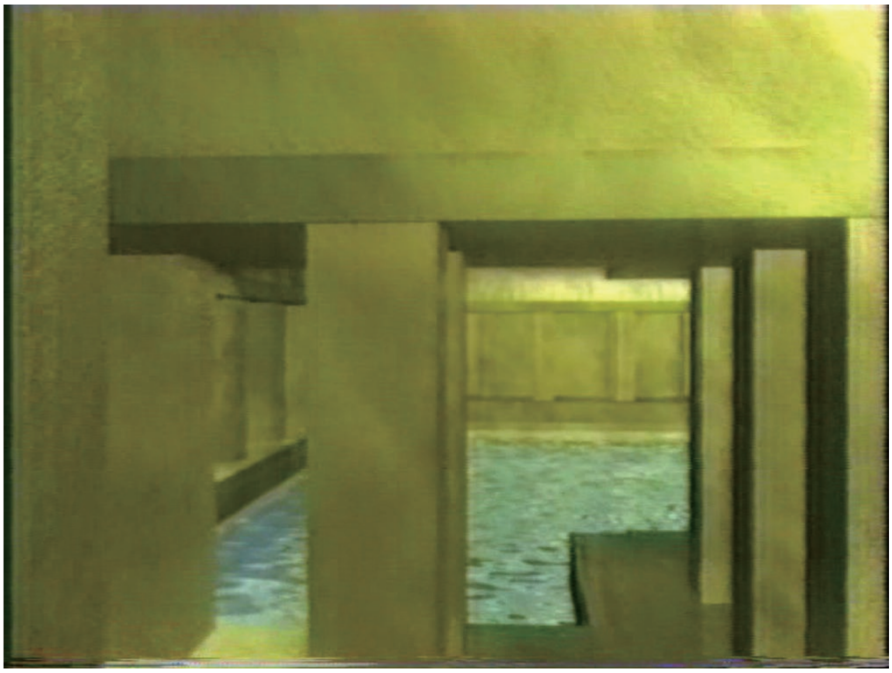
The drawing confirms the small artificial embankment (footway) parallel to the bottom of the Baray, conveying water to the upper fields.



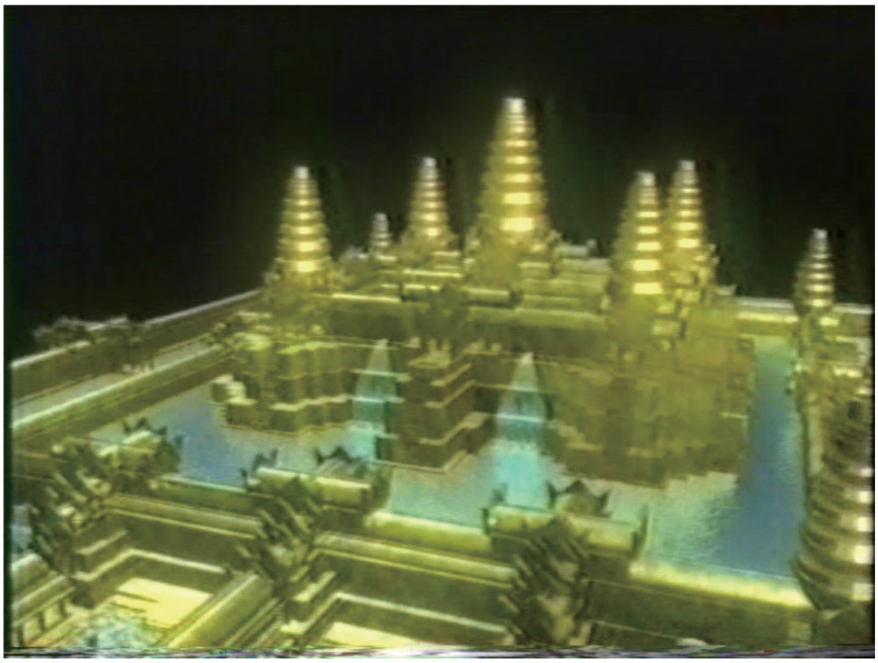
Water from the baray (reservoir) enters the lower paddy field (Tagoshi irrigation), and after the rice plants have taken root, the water is drained once again to the next lower paddy field and rice is planted.



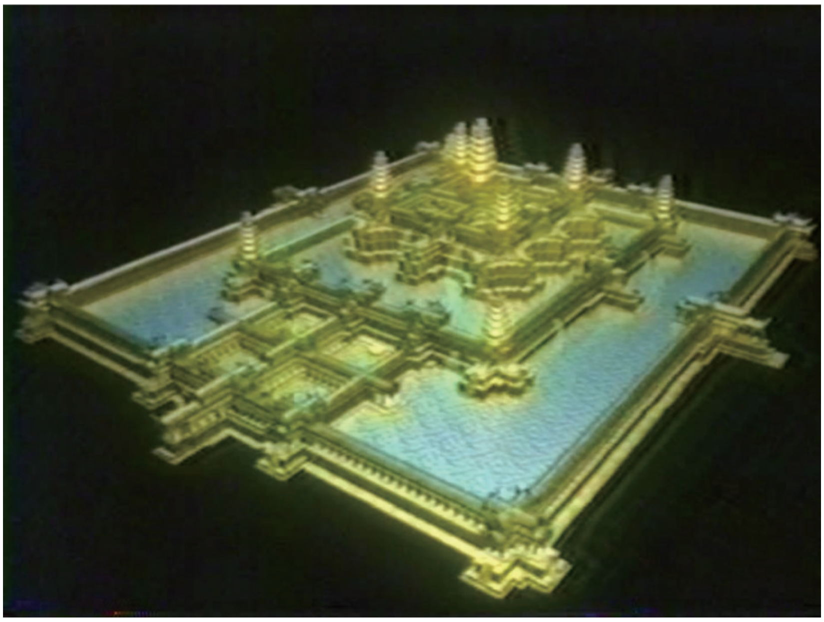
Water from the Baray was directed into the lower large paddy field, thereby enabling a second crop. At that time this was a site where double cropping was possible.



A ritual dedicated to “Naga, the god of water,” at the Angkor Wat Temple. The golden high pagoda (Mount Meru), where gods are said to reside was reflected on the surface of the water, praising the gods and creating a cycle of transmigration.



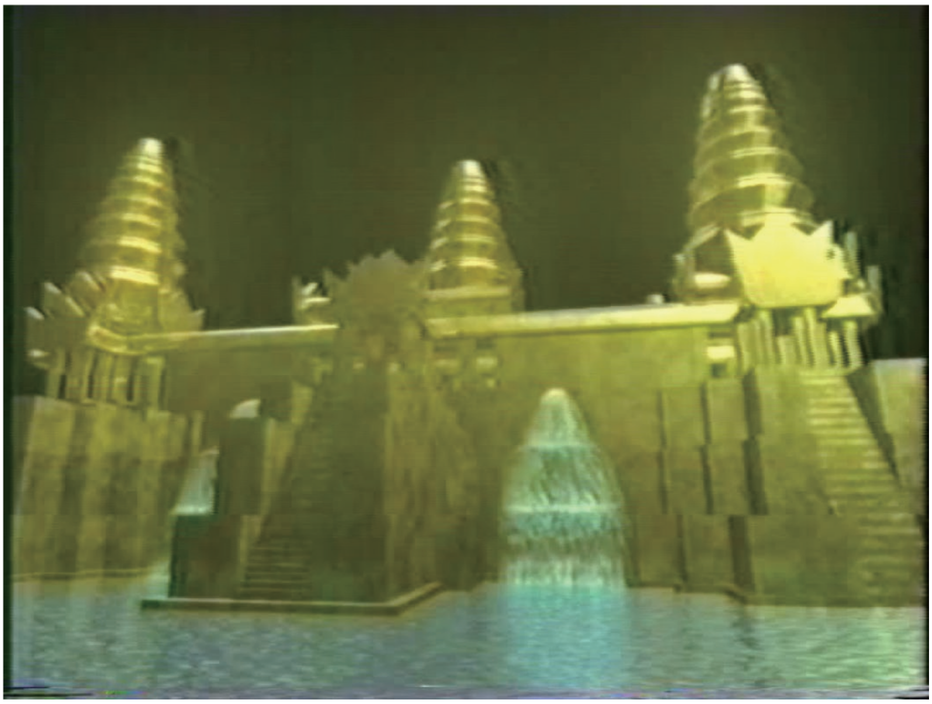
The sacred water collected in the four ponds of Angkor Wat’s third corridor was channeled into the second corridor and drained into the four ponds of the middle corridor. Villagers poured the water into bamboo tubes and drank it with medicinal herbs.



In the first corridor of Angkor Wat, there is a painting of the Churning of the Sea of Milk, and a sacred ritual was performed in front of this painting.

The spire and grand staircase of the main temple of Angkor Wat.

This is the central section of Angkor Wat. An inner garden is visible between the second corridor and the main hall. It is reported that in the past it was a large pond with a small amount of water and that the passage to the grand staircase is an overpass. Climbing the big steep staircase leads to the third corridor and main hall. The five high towers shine in the red setting sun, and the Devatas (goddesses) fill the walls of the inner court, the decorative patterns on the columns, the cylindrical windows with latticework, and even the grand staircase begin to acquire a golden glow, inviting visitors to enter a sublime world.



The ritual of Churning the Sea of Milk of “Naga, the god of water,” at the reservoir in Angkor Wat.

Relief concerning the “Churning of the Sea of Milk” in the First Corridor of Angkor Wat.

A scene from the Hindu myth concerning the “Churning of the Sea of Milk” is presented along the entire corridor, 50 meters in length. Lord Vishnu rides on the back of a giant tortoise. In order to obtain the miracle drug amrita (nectar), it is said that 88 gods on the right and 92 Asuras on the left used the body of a serpent as a rope, to churn the sea of milk. It is a forceful and dynamic scene, excellent in pictorial terms, displaying powerful arms and legs.

The Angkor Wat Cruciform Middle Corridor
This middle corridor links the first and second corridors. It has four ponds, each being around 12 meters square, and this is one of them. In those days, holy water was revered, and pilgrims washed their bodies by bathing and purifying themselves. Even the roof of the cloister is carved with fine reliefs of petal patterns and ascetical monks. There are 14 Japanese writings in Indian ink on the pillars of this corridor and among them the posthumous writing of Morimoto Ukondayu (Kanei 9, 1632), is well-known.

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Stone Hydraulic Structures in Angkor

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Until the start of the 21st century it was a convention of the archaeology of Angkor that stone was only used substantially for religious or state monuments. However, it was known from the start of research in Angkor in the 19th century that large masonry tunnels under the NE and the SW corner of the Angkor Thom enclosure wall enabled the movement of water between sectors of its exterior moat and its interior peripheral canal. The indication was, therefore, already present that stone was used for structures with a hydraulic function. How substantial this was, could have been readily apparent early in the history of research, as the massive masonry channel which forms the eastern exit of the Yasodharatataka (the East Baray) has never been invisible. What became apparent from the eastern exit of the East Baray; excavations at Bam Penh Reach on the Siem Reap River about 12 km NNE of Angkor Thom; and the use of GPR and excavation on the eastern outlet of the Indratataka was that the use of stone for hydraulics was a distinct feature of the 9th and 10th centuries. That practice is also distinctly and massively apparent in the Thmei spillway of the Northern Dam in the 10th century Koh Ker (Evans et al 2013).

Background (Figure 1)

The hydraulic network of Greater Angkor (**Figure 2**) managed the flow of water down a shallow gradient from the hills to the north and the east through the entire urban area and out to the lake. Water initially came in from the north down the ancestor of the Puok river into the proto *baray* of the urban area around Ak Yum, putatively Bhavapura in the 7th-8th century; then from the eastern side of the Angkor region down the Roluos river into Hariharalaya in the 8th-9th century; and then, beginning in the late 9th and early 10th century, from the NE down the Siem Reap river whose direction of flow was drastically modified to take the water to the Yasodharatataka. In the 11th century water was brought in from the NW and the north to the West Baray and finally in the late 12th century again from the north into the Jayatataka. The channels and reservoirs required structures to control water intake and dispersal. Of the three structures discussed here in chronological order, the first two - the eastern exits of the Indratataka and the Yasodharatataka were outlet channels for dispersing water from the *baray.* The third at Bam Penh Reach was a control structure to divert water, manage its flow and direct it down to the intake to the Yasodharatataka.

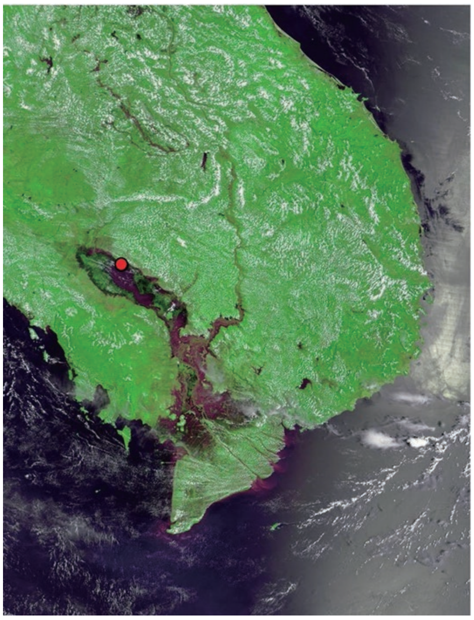

Figure 1. Greater Angkor regional location (MODIS image)

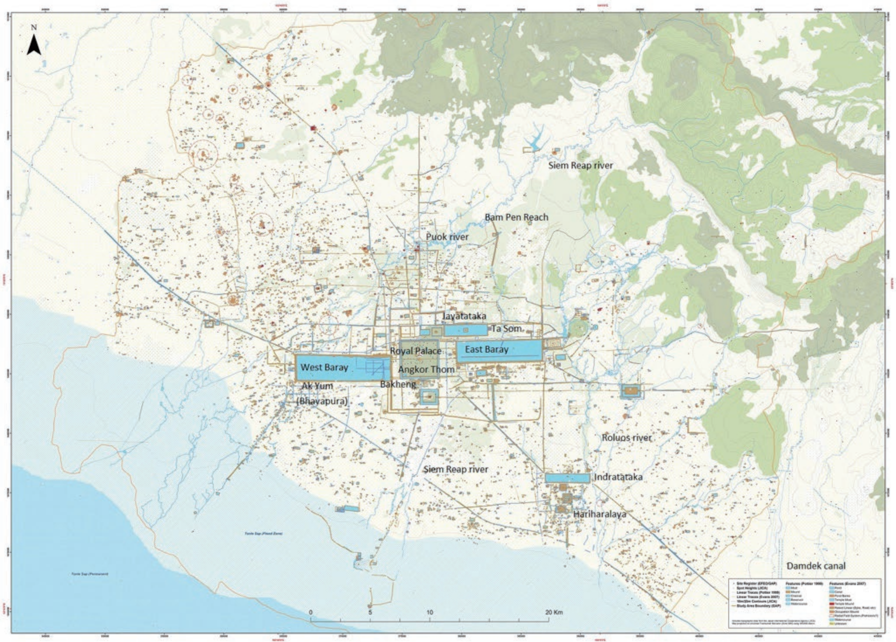

Figure 2. Greater Angkor water system – locations (GAP – Evans and Pottier)

Indratataka East Exit (Figure 3)

The Indratataka is the *baray* of Hariharalaya, the old 8th-9th century urban area in the SE of Greater Angkor. According to inscriptions it was built in the reign of Indravarman I (877 to circa 890 CE) when the visible masonry structure of the Bakong was being built. The *baray* is 3.8 x 0.75 km and today has banks 50-100m thick and about 2-3m high. Today there is an exit channel from the *baray* in its SW corner but the date of this channel is uncertain. The engineering to bring water into the *baray* is at its NE corner and tapped the water flowing southwards down the Roluos river. East of the *baray* is a linear N-S channel which appears to be the path of a former constructed canal. In the middle of the eastern bank of the *baray* is a former west to east exit canal (**Figure 4a**), part of whose line is still visible on the surface of the ground. This canal transferred water eastwards from the *baray* in the direction of the N-S canal to the east of the *baray*. In this configuration, the exit canal would deliver water that cumulated in the *baray* eastwards for redistribution both to the south into the occupation area of Haraharalaya and further south to the old SE canal that passed south of Hariharalaya and whose road embankment continued to the SE as the road to Srei Santhor (see **Figure 2**). This arrangement needs further examination of the relationship between the SE canal, the Rolous canal, and the initial form of the eastern exit canal of the Indratataka. Since the SE canal was severed by the NE Damdek canal, presumably at some time after the establishment of Greater Angkor centered on the Bakheng and the Royal Palace, this arrangement would have become redundant.

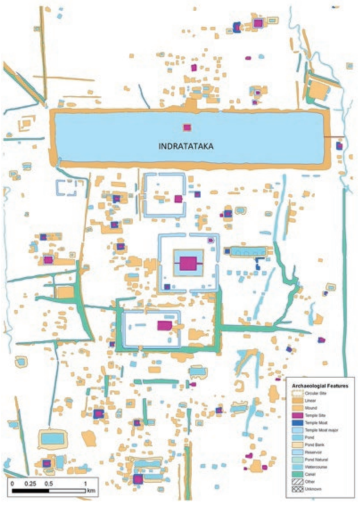

Figure 3. Indratataka and Hariharalaya area (detail from Figure 2)

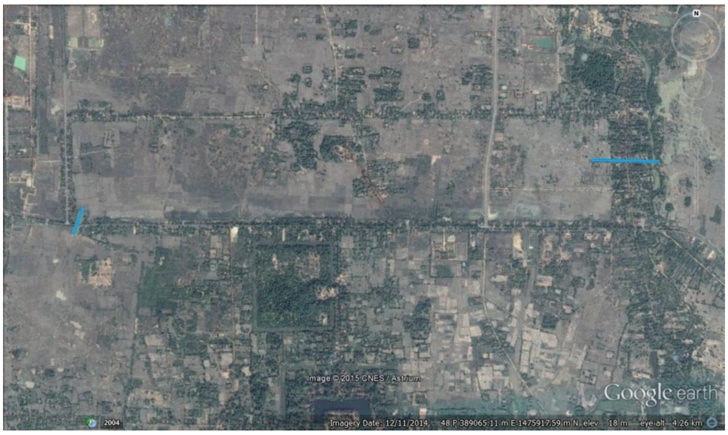

Figure 4a. Indratataka eastern exit channel plan

The west to east exit canal passed through the east bank of the *baray.* The line of the buried canal was identified using GPR (Sonnemann 2015; 2023: 35) (**Figure 4b**) and sections were then excavated across it by the Greater Angkor Project team. The GPR had indicated that the canal was steep-sided and had a wide, flat floor about 8-10 m wide which gave a strong GPR signal suggesting a hard surface. Excavation revealed that the canal was floored with irregular, flat laterite slabs (**Figure 5**) and that some parts of that paving had disappeared. The paving may perhaps have been damaged by heavy water flow and/or deliberately removed during demolitions when the exit canal was being filled with sand. As yet the date of this event is unknown. It may be as early as the construction of the Damdek canal or as late as the water crises of the first half of the 13th century or the middle of the 14th century (Fletcher et al 2017). But its effect was to convert the *baray* into a holding tank for water. As this could then be drained from the lowest point in the SW corner this was, perhaps, when that exit was created. Such an arrangement would have facilitated the storage of water brought in from the Rolous river system at the NE corner of the *baray* to be redistributed at the SW corner southwards down into the main occupation area of Hariharalaya. Whether any of that water would have passed down to the SE canal is unclear.

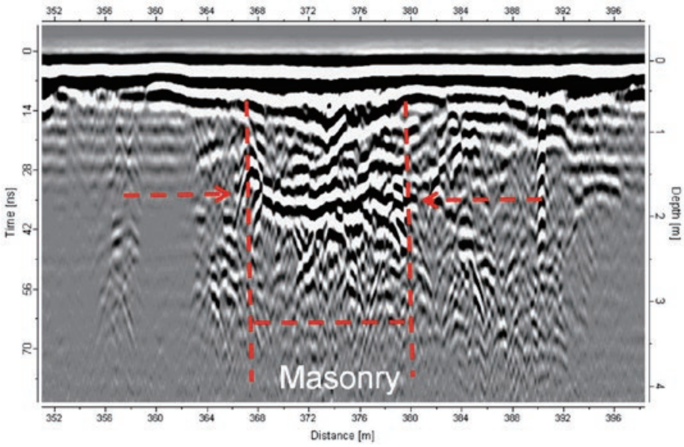

Figure 4b. Eastern exit GPR cross-section (courtesy Sonnemann)

Figure 5. Indratataka east exit channel stone pavement (GAP)

The location of an eastern exit channel of the Indratataka is consistent with the eastern exit for the East Baray and also later for the West Baray, whether or not there were any other exits. As all three *baray* have entry points for water at the upslope NE corner there appears to have been an overall consistency of arrangement for these features from the mid-9th to the early 11th century. And perhaps this pattern is even older as the circa 8th century proto-West Baray (see **Figure 2**) (Fletcher and Pottier 2021: 728-30) associated with Bhavapura also had a water channel entry at the NE corner. Assessing the rest of the form of that *baray* is problematic because its former south bank is badly damaged and its east bank is obscured by erosion and by sediment within the West Baray.

East Baray (Yasodharatataka) East Exit (Figure 6)

The inscriptions of Yasovarman I on the stelae at the corners of the East Baray indicate that the construction of the reservoir occurred at the start of his reign, which began in 889 CE. The *baray* was 7.5 x 1.8 km with banks about 100-150 m thick and now 4-6m high. There are several gaps through the banks but only one, in the middle of the eastern bank has features which date it to the 9th century. The feature which was the exit canal of the East Baray is today called Krol Romeas (**Figure 7a**) and consists of an E-W channel about 40 m wide and nearly 100 m long with walls on its north and south sides (**Figure 7b**) of squared laterite masonry that are more than 5 courses high (**Figure 8**). A low masonry structure crosses the channel about 25 m in from its western end. That structure is accessed, at its north and south ends, from the top of the main walls of the exit channel, by laterite staircases which have elaborate carved balustrades on each side (see **Figure 8**).

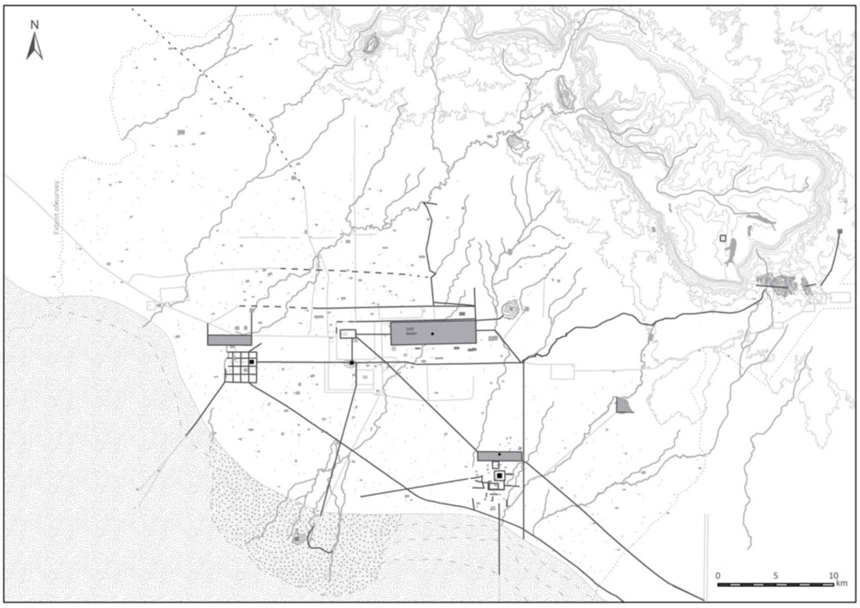

Figure 6. Yasodharatataka (East Baray) location (Fletcher and Pottier)

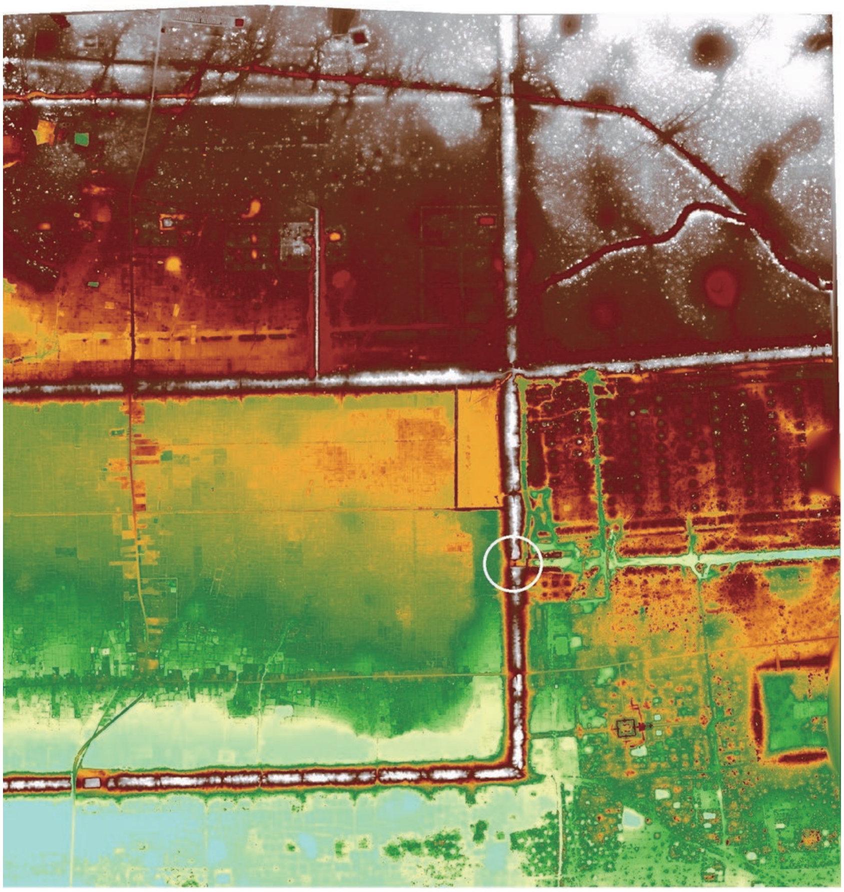

Figure 7a. East Baray east exit, lidar image showing eastern canal; and the later north-south canal along the east side of the northern half of the east bank of the *baray* (KALC 2012 image)

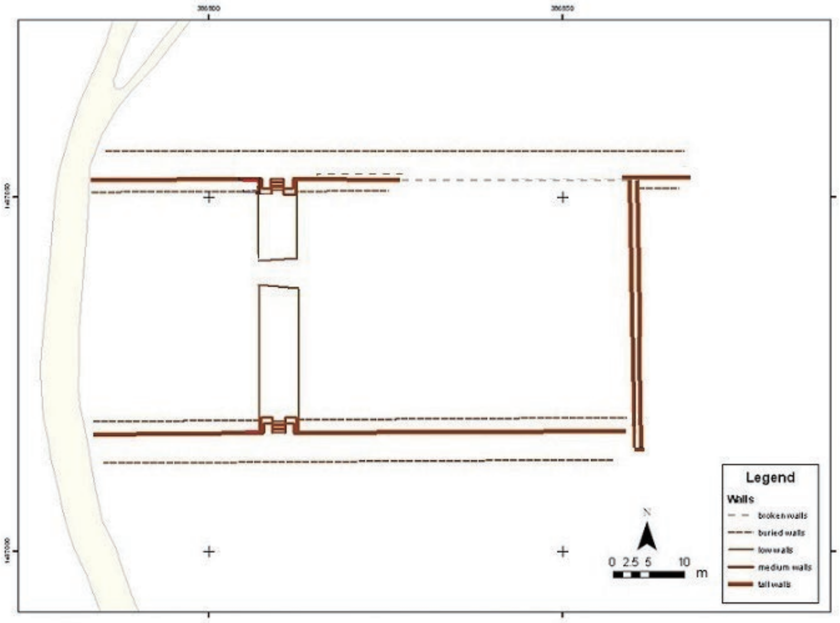

Figure7b. East Baray east exit channel plan showing the cross-wall and the eastern barrier wall (GAP – Wilson)

Figure 8. Long walls of the East Baray east exit channel and balustrade of cross-wall staircase – south side, view from west (GAP)

Figure 9. Barrier wall at east end of the east exit channel – view from west (GAP)

The masonry of the main walls of the eastern exit is characteristic of the 9th century. At its eastern end the exit channel was originally open to a wide canal with earthen banks, east of the *baray*, which flowed from west to east and then turned southwards to take water towards the Indratataka (**Figure 6**). As that canal is lower than the masonry pavement floor of the exit channel a series of masonry steps must have managed the flow down to the external canal from the level of the water in the *baray*. That part of the exit is, however, now concealed by a N-S wall of Bayon style masonry which closes off the eastern end of Krol Romeas, indicating that at a date in the 12th-13th century the exit was no longer used to direct water eastwards (**Figure 9** and see **Figure 7a**).

Figure 10a. Vertical indentation in north wall of the east exit channel view from south (GAP)

Figure 10b. Post holes in masonry pavement of the east exit channel view from south (GAP)

The original walls of the exit canal are a strong demonstration that substantial use of masonry and expert work by masons was part of water management in the 9th century. The large masonry blocks are meticulously cut and assembled and the carving of the balustrades is of high quality. In addition, the exit canal was paved with flat, irregular laterite slabs, as in the eastern exit canal of the Indratataka. What is especially significant, however, about the east exit of the Yasodharatataka is that it was modified several times and in its original form appears to have had some form of sluice gate structure located approximately where the low wall now crosses the canal. Shallow vertical indentations about the width of a wide plank are carved into the faces of the northern and southern walls just to the west of the cross-wall (**Figure 10a**). Excavation of the pavement of the exit canal along several metres of the western face of the cross-wall revealed that a structure of large wooden post had preceded the cross-wall and presumably formed a row or rows of post from N to S across the canal (**Figure 10b**). The implication is that these formed a substantial timber structure like a bridge providing access along the top of the east bank of the *baray*. The vertical indentations appear to be places where several thick planks were fitted against the masonry wall, where they would have been held in place by a structure under the bridge. This needs further attention as it may be evidence of an elaborate system of sluice gates which were managed from the top of the bridge and controlled the flow of water from west to east out of the *baray*. If this was the case then a remarkable piece of mechanical hydraulic engineering was developed by the Khmer engineers in the 9th century.

For as yet unknown reasons the timber bridge was then replaced by the cross-wall which may have had a central gap through which the water flowing out of the *baray* was later managed. The use of laterite masonry for the stairways whose major blocks resemble the original walls suggests that this change was made within the 9th-10th century though that needs further appraisal. The management of water in Krol Romeas also needs further attention because there are a vertical set of circular holes cut into the main laterite walls of the channel about 5 m from current west end of the walls of canal. These would have held timber beams running across the canal, presumably held in place by vertical posts embedded in the masonry pavement of the canal. Such a structure could have held a matting dam in place which was periodically cut away to allow water to flow eastwards. How this might have related to the cross-wall and the wooden bridge structure, further east is not clear. Nor is the date of that timber beam structure.

What is indicated is that the east exit of the East Baray had a potentially elaborate history, which is further demonstrated by the structure of the eastern barrier wall and a small masonry-built channel associated with it that took water SE from the SE corner of Krol Romeas (Sonnemann 2023: 33-34) (**Figure 11**). The eastern barrier wall was built in sectors several metres long with the portion at the northern end of wall being the final blockage of the eastern exit of the *baray*. On the east side of the barrier wall against the end portion of old northern wall of Krol Romeas there is a small conduit built of masonry. From the southern end of the barrier wall a much more substantial channel which took water diagonally way from a gap between the southern wall of Krol Romeas and the barrier wall (see **Figure 11**). This SE channel and small conduit would have served to drain water from the eastern exit, though their exact functions and their relationship and dates are not known, except that they would from the 12th - 13th century on the basis of the masonry used in the barrier wall. That wall was part of a radical reconfiguring of the eastern exit to convert it into an inlet to the *baray* Water was brought southwards from the NE corner of the *baray* in a north-south canal cut into the eastern side of the east bank of the *baray* (see **Figure 7**). As much as 20 m of the eastern end of the original north wall of Krol Romeas was demolished and replaced by a row of narrow masonry sluices across the end of the north-south canal (**Figure 12**). These narrow sluices could presumably be blocked and opened in various combinations to carefully control the flow of varied quantities of water into Krol Romeas and thence into the East Baray. What is significant about the N-S canal is that it brings water from exactly the same point at the NE corner of the *baray* where water coming down from a large zig-zag canal would originally have entered the East Baray. Therefore, the source from which water was supplied to the East Baray did not change, only the point at which it was brought into the *baray*. The implication is that though the source was the same the amount of water being supplied had decreased markedly and could only be expected to fill the southern half of the East Baray, essentially to the south of the line of what is now Pradak village which is located within the *baray*. Had that reduced water flow been directed into the NE corner of the *baray* it would have sunk into the bed of the *baray* and been hard to retrieve. Only by taking that diminished amount of water into the southern half of the *baray* could a standing body of water be produced. The old eastern exit was repurposed as an inlet because it could no longer serve to distribute large amounts of water eastwards into the SE portion of Greater Angkor from Hariharalaya eastwards to the Damdaek canal. Instead, the East Baray was converted to act as a holding tank for a limited supply of water.

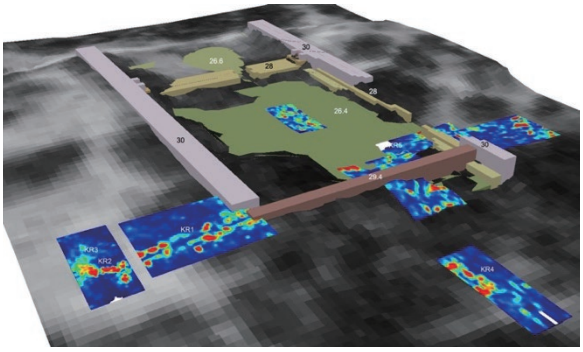

Figure 11. Masonry channel at SE corner of the east the exit channel – GPR image (courtesy Sonnemann).

Figure 12. Sluices on north side of east exit channel at the NE corner – view from north (GAP)

A time when this conversion of the East Baray would have been necessary may be the period between the 1220s and the 1250s when the fluctuating size of the monsoons cumulatively decreased to a low point around the middle of the 13th century (see Buckley et al 2014: **Fig 6**). An intriguing issue is that although the monsoons recovered in the second half of the 13th century –

before their catastrophic de-stabilisation around the mid-14th century – the East Baray's eastern exit was never reopened and restored to its original purpose. As with the Indratataka the changes to the east exit of the Yasodharatataka appear to indicate a permanent change in the way the *baray* were used and also more broadly how water was used and managed in Greater Angkor.

Bam Penh Reach Spillway Dam (Figure 13a)

The Bam Penh Reach spillway dam is deeply buried and was badly damaged by some combination of erosion and demolition. The remnants of the structure were only noticed because in the 1970s a water channel was cut through its location by the local Khmer Rouge in the 1970s to enable the movement of water between the abrupt southward turn of the Siem Reap River at Bam Penh Reach and the lower-lying land to the west (**Figure 13b**). What was first observed by Vân Sary, who was carrying out a survey for Christophe Pottier, was a few, shaped, laterite blocks in the bed of the channel. Later excavation revealed a large surface of carefully laid blocks (**Figure 14a**). Further inspection by Pottier and Fletcher identified that the channel had cut through a sloping, stone-surfaced structure that sloped down from east to west (**Figure 14b**).

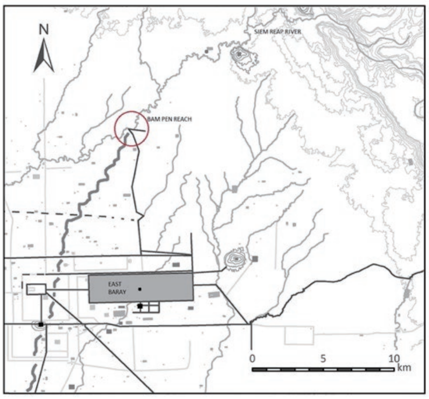

Figure 13a. Location of Bam Penh Reach (Fletcher and Pottier)

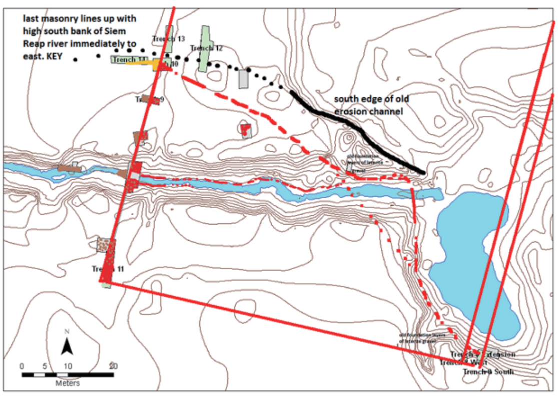

Figure 13b. Plan details and excavations at Bam Penh Reach (GAP – Wilson)

Figure 14a. Blocks of the western kerb of the spillway in bed of the Khmer Rouge channel – view from north (GAP)

Figure 14b. Blocks in sloping surface of spillway in the bank of Khmer Rouge channel – view from west (GAP)

The large, shaped and interlocked laterite blocks in the bed of the channel were part of the front kerb of a structure which was aligned approximately North-South (see **Figure 14a**). This kerb was six courses deep and was found by excavations both north and south of the KR channel on the predicted line of the western edge of the structure (**Figure 15a**). To the north it was apparent that edge of the structure was broken away only about 20 m north of the channel and that its broken remnants were buried by layers of gravel and sand (**Figure 15b**). Excavations revealed the surface of the pavement of laterite blocks sloping down to the west which formed the surface of the structure. The profile suggested that there should be an eastern side to the structure. A short remnant of this edge was located in the steep southern side of a large, deep depression containing a large pond near the Siem Reap River (**Figure 16a**). This edge was built of steeply sloping, carefully-shaped laterite blocks bedded at their base in a thick, concrete like material. The remaining blocks formed two layer and sloped up to the east indicating that high up in the profile of the side of the pond they would meet the shallow gradient of the masonry pavement which sloped down to the west. By projecting the slope of the steep blocks of the western edge it was possible to predict where that junction would. The junction was made of carefully worked laterite blocks, one of which was the crest block with two sloping surfaces meeting in the middle (**Figure 16b**). The crest line ran approximately North-South. The structure was therefore a spillway dam with a crest whose height defined the maximum level at which water could be retained behind the dam. If the water level to the west, in the Siem Reap River, rose higher than the crest it would flow over the crest and then westwards down the western slope of the spillway dam. West of the spillway dam the water flows westwards to eventually debouch into the Puok River west of the current N-S axis of Angkor Thom.

Figure 15a. The western kerb of the spillway in Trench 6 – view from south (GAP)

Figure 15b. Broken end of the western kerb of the spillway in Trench 10 (GAP)

Figure 16a. Sloping eastern face blocks of the spillway in Trench 8 – view from north (GAP)

Note: the right-hand image shows the thick layer of "concrete" which covers the basal blocks of the east face
Note: the crest block is visible in the top right of the left-hand image

Figure 16b. The crest blocks of the spillway in Trench 8 west – left-hand image - view from north (GAP), right image – vertical view (GAP)

The spillway dam was a remarkable, simple, and sophisticated feat of hydraulic engineering (**Figure 17**) approximately 100 long and about 80-90 m wide, originally blocking the Siem Reap river valley just to the west of the huge canal offtake which took the water of the river southwards to the East Baray (**Figure 18**). The spillway controlled the maximum level of the water which could flow down the canal and would have prevented high water flow in the river from damaging the offtake canal and the East Baray by allowing it to drain away to the west. The crest block is, therefore, a profoundly significant engineering achievement as it defined the maximum height of the water flow in the entire water network to its south by setting that water level down the entire length of the feeder canal to the East Baray; the level which the water could therefore reach in the *baray*; and consequently the maximum height it could reach flowing out of the eastern exit of the East Baray; and thereby the water level in the canals further downstream which it supplied with water.

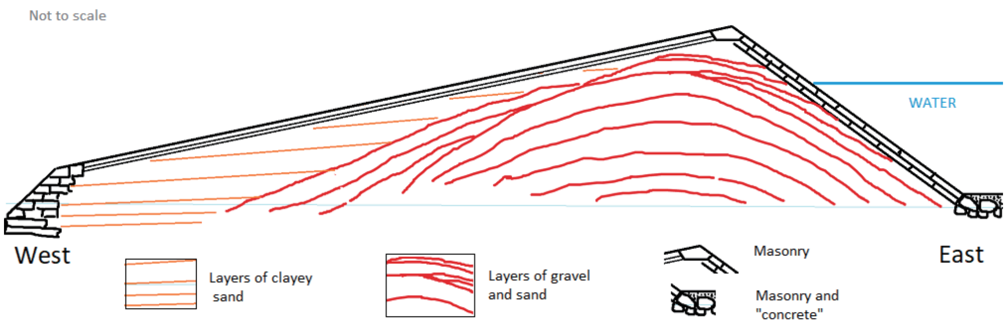

Figure 17. Schematic cross-section of the spillway (GAP - Fletcher)

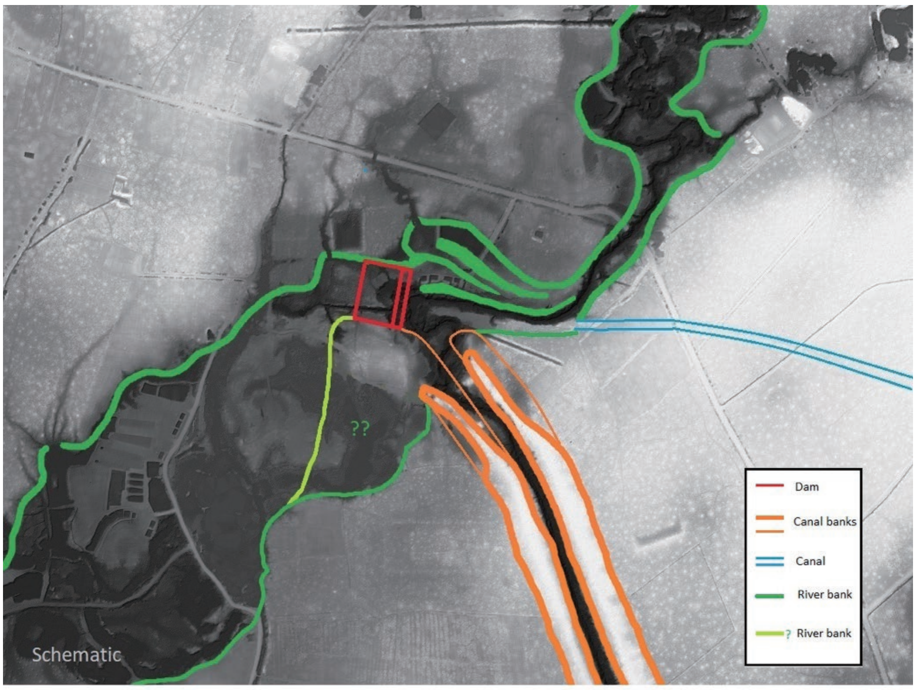

Figure 18. The system of Bam Penh Reach (GAP - Fletcher) – (see below for base image from CALI 2015)

At some time between the 10th and the 11th-12th century a deep erosion channel, visible in Trenches 14 and 10, gouged through the spillway (Fletcher and Pottier 2021: 737). This may have been due to extreme natural waterflow beyond the capacity of the dam and its southward channel to the East Baray, either due to direct water erosion or because the engineers intervened and broke the dam to release excess water and prevent it from destroying the massive zig-zag canal going south to the East Baray. Only the southern end of the spillway has survived (see **Figure 13b**). The damage was a complex process, involving the disappearance of the bulk of the spillway dam due to the removal of large quantities of masonry probably due to water flow, then the deliberate removal of some masonry, as is indicated both at the northern end of the western kerb of the spillway (see **Figure 14b**) and in the possible leverage of blocks in the sloping surface of the spillway, followed by the burial of the structure under layers of laterite gravel and sand.

After the spillway dam was damaged and buried, the location was substantially re-modeled by the addition of a massive sand dam across the valley whose southern end is still extant as the high ground south of the Khmer Rouge channel. The sand of this new structure also filled in the wide erosion channel referred to above. The remains of the southern end of the spillway dam were completely covered by sand to a substantial depth above the sloping blocks (see **Figure 16a**). It is not clear how much erosion has occurred since then but the ground surface to the south of the KR channel is several metres higher than the top of the spillway dam. The form and profile of the sand dam is a substantial issue. It was necessary to block the Siem Reap River and direct the water southwards into the main canal after the spillway had been ruptured. The lidar (**Figure 19**) indicates that the short northern portion of the ends of the two embankments of the massive zig zag offtake canal to the south, which angle to the WNW, may be of a different form to the main

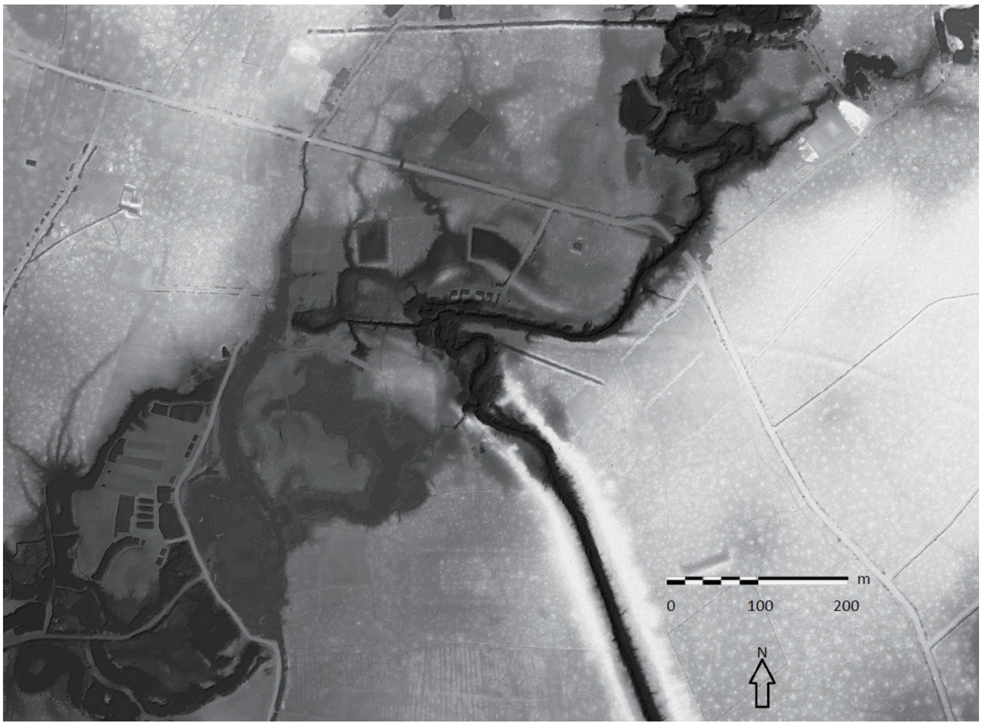

Figure 19. The features of Bam Penh Reach (CALI 2015)

banks. If this is the case these angled banks may have been added to the ends of the original embankments to somehow align the older banks of the main canal with the later sand dam. This will also require substantial hydrological modelling as the bulk of the sand dam has been eroded away. That erosion may have been a consequence of the mega-monsoons in the climate fluctuation crisis of the 14th century when the water flow in the Siem Reap River could have overwhelmed the dam.

To the east of the spillway dam were several other features whose relationship to the spillway dam is not clear. They may relate to the large dam which superseded the spillway. On the bed of the river valley are three, now badly damaged, curved banks on the floor of the valley which extend from the narrow part of the valley further to the east, towards the location of the spillway dam (see **Figure 18**). A possible function may have been to direct the flow of the water into a large pond behind either the masonry spillway dam or its sand-built successor. These banks perhaps divided up the water flow of the river reducing its direct impact on the back of the dam. Modeling of the hydrology of that pond will be needed to assess how to test the proposal. Another significant feature is a canal that exits the south side of the valley to the east of the dam location (see **Figure 19**). This canal is visible on the lidar and was seen in aerial images as a wide band across the field south of the Siem Reap River, next to the road over the bridge across the river. This canal trends towards the SE away from the dam locations and would have served to take overflow water down into the next river catchment to the south of the Siem Reap River. Noticeably, that catchment is characterised by numerous natural ponds and does not appear to contain very much occupation. This would be consistently with the area being flooded regularly by overflow from the Siem Reap River. As the function of the spillway dam was to relieve excess water flow by dumping it to the west the function of the exit canal taking excess water to the southeast is more likely to have been part of the massive sand dam - which presumably did not have or could not incorporate a spillway feature in its structure. Because the Bam Penh Reach area contains two major Angkorian water management systems, and perhaps more if we include the river catchment just to its south, this region would be a key location for understanding how water management changed during the Angkorian period and also the degree of resilience which enabled the engineers to overcome whatever damaged the masonry spillway dam and/or required its replacement by a huge sand dam.

Implications

The three masonry structures are all associated with the 9th century *baray*. Two of the three are the masonry exit channels in the eastern banks of the Indratataka and the Yasodharatataka, which were at some later date, perhaps as late as the 13th century taken out of commission as exit points for water due to the long fluctuating decline in the monsoons in the first half of the century. The third, at Bam Penh Reach was a masonry spillway dam across the Siem Reap River which diverted the river southwards into the large zig-zag canal which took water to the NE corner of the Yasodharatataka. This structure appears to have been damaged and perhaps partially demolished in the 11th century and was then superceded by a massive embankment dam of sand, which completely buried the earlier structure. Broadly, these histories indicate that alternatives to masonry control of water on a large scale may have been increasingly used from the 11th century onwards though not necessarily due to the same issues or following the same format. In this context particular interest focuses on the West Baray whose eastern exit channel is clearly recognizable east of the *baray* but whose form is, as yet, unknown within the east bank of the *baray*. This now appears to be a further example of the infilling of a former exit channel. A possible date for this infill is suggested by the marked change in the 13th century in the sedimentation in the pond of the West Mebon of the *baray* (Penny et al 2007). Interestingly, the Jayatataka, which was built in the late 12th century, does not appear to have had a substantial eastern exit channel, unless it is comprehensively concealed by or was destroyed by the Ta Som temple enclosure. The water from the Jayatataka was, instead, directed through a channel in its southern bank (Hang Peou 2009) and flowed westwards into the Angkor Thom moat and also originally flowed southwards past the Ta Keo (Klassen et al 2021), again suggesting that a substantial change in the way water was managed through *baray* was occurring from the late 12th century.

Conclusions

The eastern exit channel of the West Baray and the eastern bank of the Jayatataka may contain crucial indicators of the way in which the management of water began to change in Greater Angkor after the start of the 11th century. In addition, detailed attention to Bam Penh Reach and the construction of the major sand dam over the top of the masonry spill way dam may also clarify how that change was managed further upstream. In Bam Penh Reach the peak blocks of the spillway which still survive at the southern end of the masonry dam are a fundamental and profound demonstration of the immense hydraulic expertise of the 10th century Khmer engineers. Those blocks defined the water levels downstream for the entire eastern half of Greater Angkor until they were buried by the sand dam. The closing of the Eastern exit of the Yasodharatataka and the infill of the easter exit of the Indratataka were perhaps part of a single, perhaps urgent remodeling of the entire water network in the first half of the 13th century in an effort to stockpile sparse water in the *baray* as huge holding tanks. If this was the case they represent a significant example of the versatility, pragmatism, and technical flexibility of the Khmer water engineers, who displayed a substantial ability to devise new ways to deal with difficult circumstances and manage a decreasing water supply. The final path of the then Siem Reap canal southwards through the location of the Spean Thma may also be part of this necessary reconfiguring of the water system. A substantial program of dating and further research on all these structures would be a major contribution to our understanding of the expertise of the water engineers of Angkor. The transformations of the water network of Angkor were ongoing. Its operation and re-use were a dynamic practise, not a static tradition.

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The Gift of Water in Khmer Epigraphy

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Abstract

Twenty-seven years after the paper, "*L'eau dans l'épigraphie*" ("Water in Epigraphy"), was presented by the late Claude Jacques' at the "Angkor and Water" symposium held in Siem Reap in June 1995, I revisit this important theme by completing and revising his original contribution.

Not only have scholars added many epigraphs to the inventory of Cambodian inscriptions that were unavailable at the time, and advanced computation designed for philology has also progressed considerably, and it stands to shed critical new light on the content of these texts. Such digital datasets provide new clues on the gifts of water facilities in the inscriptions, and they enable the search of all the epigraphic occurrences of the lexical field associated with this topic.

When possible, we will present pointers to this subject in Indian ritual treatises, which profoundly influenced the religious practices of ancient Cambodia.

Ultimately, this paper aims to contribute to a more comprehensive image of Water in Ancient Cambodian culture.

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In 1995, the late Claude Jacques presented a paper on *Water and Epigraphy* that began with this sentence: "Water is one of the elements that allows us to measure to what extent Khmer epigraphy cannot reveal everything about the Khmer past: apart from rare exceptions that are all the more notorious, water is indeed surprisingly absent from these poems that the builders wanted to have engraved on the doorposts of the god's house or on a stele placed not far from his eyes".

This scarcity of references to water is indeed troubling in a tropical country, especially in the case of a kingdom with a rural economy dependent on the monsoon where the question of water management was obviously crucial. It is also surprising from a ritualistic point of view given the importance of water for purifying baths or other rituals in the Indian tradition, which has played an important role in Cambodia. In Indian treaties, the rules governing the installation of a reservoir, the *puṣkariṇīpratiṣṭhā* or *taṭākapratiṣṭhā*, testify to the importance of these facilities, whether or not they were associated with a temple. The rules and ceremonial conventions are

1 This conference was presented at the Sophia Asia Centre in November 5th 2022. It was prepared in the framework of the "Corpus des inscriptions khmères" (CIK) and the Yaśodharāśrama research programs, which form part of the DHARMA project funded by the European Research Council (European Union's Horizon 2020 research and innovation programme; grant agreement no. 809994). The English translations of the French sources are by the author.

notably presented in detail in chapter 4 of the *Somaśambhupaddhati,* where it is stated that the same ritual governed the construction and use of reservoirs of different sizes, from small basins to massive hydraulic structures like the Khmer *barays*. This text also demonstrates the complexity of the ritual in question: it starts with a *vāstupūjā*, performed on a grid of 121 squares, followed by the worship of Kālāgni and eight other gods on the pericarp and the eight petals of a lotus respectively. In the next step of the ritual, the eight mythical snakes of the underworld are worshipped and installed in silver images within the excavated pit prepared for the tank, while the propitiation of demons is also performed in an outside pavilion. Furthermore, eight flowers and several other objects are placed in the pit, such as gems, a lotus, the five products of the cow, and so forth. Finally, an object called "snake-rod", representing the snake Ananta, is ritually deposited inside the excavated depression. Following the conclusion of these rites, the officiant must cross the tank holding onto a cow with the help of a silver chain, which symbolizes his crossing the river of hell, Vaitaraṇī. The rite finishes with fire oblations, rice-offering, and donations made to the guru. (*Somaśambhupaddhati*, chapter XII; Brunner-Lachaux 1998: xxx, 392-403).

In the same vein, general architectural treatises, such as the *Mayamata*, document the ritualized installation of water reservoirs. The latter treatise emphasizes the importance of properly locating and constructing these hydraulic structures in conformance with established religious prescriptions and conventions:

Where and When to Establish a Well?

It is said that in a village or other settlement, a well (established) in the south-west corner (brings) the torment of disease; in the west it increases the cattle, in the north-west it (brings) death (caused) by the enemy, in the north it gives all happiness, in the north-east it makes one attain prosperity.

Candragupta says:

"In the fields and gardens a good well is in the North-East or in the West"

Varāhamihira says:

"If a well is in the south-east corner of a village or town, it causes men perpetual fear and certain death; a well in the south-west corner is the loss of fortune, and in the north-west, the loss of a wife. A well dug in any of the directions, except these three, is a source of success."

Mayamata, appendix 1-5 (Dagens 1976: 482).

The very fact that this topic, the installation of a tank, a basin, a well, is given little or no treatment in treatises such as the Śaivite *Agāmas*, suggests that this ritual was widely shared and understood and thus transcended sectarian divisions. In other words, it was so commonplace and obvious it required no mention. Therefore, the scarcity of references to water, as essential to the ritual and profane activities of the Khmer daily life, which so puzzled Claude Jacques, would no longer seems remarkable; water rituals were so essential and ubiquitous that they did not require discussion.

However, scholars have added many epigraphs to the inventory of Cambodian inscriptions that were unavailable at the time, and electronic tools devoted to philology have also progressed considerably, and it stands to shed critical new light on the content of these texts. Such digital datasets provide new clues on the gifts of water facilities in the inscriptions, and they enable the search of all the epigraphic occurrences of the lexical field associated with this topic. In the end, such programs permit an interesting update to Claude's first overview of water in Khmer epigraphy.

Moreover, it deserves mention that Claude's survey of references to water concentrated on the Sanskrit parts of the inscriptions. Indeed, he focused mainly on the royal foundations, starting with the *baray*, *taṭāka* and the moats, *parikhā*, *vāpī*, as well as poetic eulogies of the Jayasindhu, "ocean of victory", in the case of Angkor Thom.

It is true that the great campaigns to construct waterworks were among the major public projects undertaken by the Khmer rulers at the beginning of their reign in order to ensure the prosperity of the region and to honour the deities with considerable donations. The scale and duration of these major projects were so great that their reign often did not witness their completion. For example, the Yaśodharataṭāka, the eastern baray was commissioned at the end of the 9th century, but all the evidence suggests that the building project was continued by his sons, who reigned longer than he did, even though no large-scale foundation is attributed to them. This is moreover consistent with the dating of the occupation of the *āśramas* to whom the protection of the baray was entrusted, institutions that I have been studying for more than 10 years (Estève and Soutif 2010-2022). Moreover, the final completion of this baray must be linked to the foundation of the Mebon in its centre, which was founded by King Rājendravarman during the second half of the 10th century.

Claude Jacques also studied the dimensions of the water features linked to the great temples of Jayavarman VII, Ta Prohm and Preah Khan, the measurements of which are specified in the foundation inscriptions of these temples. Indeed, the stele of Prah Khan reports 93,507 fathoms of perimeter combined for 32 basins, the Jayataṭāka, or Baray of Neak Poan included. At Ta Prohm, the stele documents 76 fathoms in width for the *vāpī* and *taṭāka*, and, in all, 1150 (fathoms) in length.

The monumental size of the facilities bears witness to the prodigality of the donor and it is thus not surprising that such donations were celebrated in Sanskrit poems.

Nonetheless, Claude did not limit himself exclusively to the royal foundations and also referred to the large-scale building programme of an architect and high dignitary of Rājendravarman, Kavīndrārimathana. He discusses in particular his foundation of the Buddhist temple of Prasat Bat Chum, emphasizing the inscriptions that commemorate the moats, and the purity of its waters reserved for the brāhmans:

"He did this moat, which gives purification with its clear water, as science gives nirvana."

“In accordance with Buddhist rites, he built this moat to bring joy to all beings, honoured by the great, and helping the Dharma to prosper.”
“In the sacred water of this moat worthy of the bath for the king’s swans, only the king’s purohita and the brāhmans will be allowed to bath, such is his wish.”
(K. 268, st. XXXVIII-XL; 10th century; Cœdès 1908: 240, 247, 252).

As we can see, poems extensively describe the moats or similar water features and compete to celebrate their size, their benefits, and their purity. In his conclusion, Claude himself noted that mentions of hydraulic equipment were not that rare, but by focusing only on the facilities mentioned in the Sanskrit poems, he failed to capture the full Khmer reality of that period. In fact, by broadening the lexical field in ancient Khmer, we find many more mentions to hydraulic infrastructures, which, although more modest, are nonetheless omnipresent in Khmer epigraphy.

The Khmer lexical field associated with water, listed below, is not very varied.

First, there are a few rare references to specific facilities, and the meaning of certain key words remain conjectural when they appear only as anthroponyms like *’aṁvuḥ* Philip N. Jenner interprets the latter as [conjecturally] signifying a sluice, or a break in a dike for irrigation water (2009, *s.v.*). But even if others convey a clear meaning, we only have few incidences of terms designating canals, channels, embankment and dams. In any event, we can note occurrences of:

- *raṁloṅ*, “a channel for flowing water: canal, waterway.” (Jenner 2009, *s.v.*), in two occurrences. For instance, the pre-angkorian inscription K. 1 states:

  ’ai karoṁ kyel gui pāk raṁloṅ vera

  “[...] north of the branching of the two channels”.

  (K.1, l. 20, 6th-7th *śaka*.; *IC* VI: 28)

- We also document mentions of barrages, *daṁnap*, “something which obstructs: obstruction, blockage, a barrage” (*ibid.*), well represented with 38 occurrences in 23 inscriptions as in the 10th century inscription K. 192:

  sre ’aṁvi jeṅ· vraḥ daṁnapp· cap· travāṅ· svāyā

  “Rice field from the holy dike which holds (the water of) Travāṅ Svāyā.”

  (K. 192, l. 17; *IC* VI: 128)

- *daṁro* but with only one occurrence, “embankment”*:*

  nā daṁro travāṅ jleṅ

  “[This marker is] on the embankment of Travāṅ Jleṅ”

  (K.897, 1. 1; 12th *śaka*; *IC* VI: 320).

- In addition, the term *laṅloṅ*, which Jenner interprets as ‘ditch, hole, pit, a pool’ appears in unclear contexts, except in one case in the Lolei inscription K. 947A at the end of the 9th century CE (l.19-20). In this instance, the term designates a stone adorning an object, perhaps an allusion to the way in which corundum (sapphire, ruby) was sought in a well (Soutif 2009, p. 533).

- We can finally mention the terms *’antvaṅ*, and *tnoṅ* which among other meanings, could designate “a well”, but they very rarely denote this. Instead, these terms usually refer to unidentified instruments for dipping or scooping and to corresponding measures for liquids like honey used in rituals.

Interestingly *’antvaṅ* is used to designate a well only in inscription K. 299.14[2], which threatens to hell people who destroy it. The fact that the foundation or destruction of hydraulic structures are subject to reward or imprecation respectively, echoes the Indian theoretical literature in which the gift of water for all beings (*sarvabhūta*) is often celebrated and unequivocally demonstrates their importance.

Concerning *tnoṅ*, we find it in this pre-angkorian sentence:

sre ’aṁno[y] ci dok ’āy ta vraḥ kaṁmratāṅ ’añ śrī yajñapatīśvara ’aṁvi travaṅ ruṅṅ loḥ tloṅ dikk loḥ travaṅ ji ckey loḥ travaṅ poñ rudrabhava…

“A field given by the ci Dok to the Vraḥ Kaṁratāṅ ’añ Śrī Yajñapatīśvara, from the great reservoir to the well, to the reservoir of the ji Ckey, to the reservoir of the poñ Rudrabhava...” (K. 30, l. 12-15; 6th *śaka*; *IC* II: 26)

In this case, one may wonder whether it is a question of hierarchizing water infrastructures rather than designating a well as such.

This sentence brings us back to the Khmer equivalents of the terms studied by Claude Jacques. However, they perhaps designate more modest hydraulic structures as we are dealing with administrative texts in Khmer, which often commemorate dignitaries and not royal foundations.

The Khmer word to designate a moat is *’añcan·* appearing in twelve Angkorian occurrences. K. 254B, of the 12th c. for example, reports that for the gods, a high dignitary bought land, planted markers, made fences, built walls and dug moats and ponds (*loḥ bhūmi saṅ gol thve vnāṅ semāvadhi saṅ kudya jyak ’añcan travāṅ*; B, l. 11-12; *IC* III: 180).

Concerning the reservoirs, two words were mainly in use. The first *danle* designates a major river, large waterway or a large body of water, including pond, pool, tank, reservoir, lake, or sea (2009, *s.v.*).

It is noticeable that in inscription K. 258, a *danle* is named after its founder, which underlines the importance of the structure:

[...] *nu sthāpanā cat sruk jyak danle ’āy vraḥ kapila ta jmaḥ śrī śivayogīśvarāśrama*

“[...] on this date [1000 *śaka*] I [Śrī Yogīśvarapaṇḍita] set up an image, laid out the sruk, [and] dug the reservoir at Vraḥ Kapila, which was named the Śrī Śivayogīśvarāśrama’.”

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2 This inscription is engraved in the Heaven and Hell gallery in Angkor Vat: “[The Hell] Asthibhaṅga [“Breaking of bones”]. People who, contrary to the Law, destroy with weapons gardens, houses, ponds, moats, wells, public buildings; people who destroy the tirtha of others.” (11th *śaka*; Pou 2001: 157).

(K. 258B, l. 20; 1018 *śaka*; *IC* IV: 175)

Indeed, several inscriptions suggest that it is equivalent to the more common term *taṭaka*. For instance, inscription K. 383 reports that a Guru, the Kamrateṅ 'Añ Śrī Divākarapaṇḍita *jyak danle ti hau śrīdivākarataṭāka*, "dug a *danle*, named Śrīdivākarataṭāka" (A, l. 42; 1041 *śaka*; Cœdès & Dupont 1943: 134).

Finally, in inscription K. 873 of the early 10th century (l. 14; *IC* V: 104), *danle* is also the term used for the basin of Śrīndreśvara, *i.e.* the Bakong basin, so it likely refers to the baray of Lolei, better known as Indrataṭāka. It is interesting to note that in this inscription, this waterworks is distinguished from obviously more modest basins for which the term *travāṅ* is used. It therefore seems that the term *danle* actually refers to large reservoirs.

With approximately 400 occurrences, the most common term is of course *travāṅ*, equivalent to the contemporary Khmer word *trapeang*[3].

It often appears simply in toponyms, such as *trapeang rvvau*, one of the few sanctuaries that has retained its Angkorian name, Trapeang Ropou, a temple now located near Siem Reap airport, on the road leading to Angkor Wat. These terms are also often employed as a topographical indication to locate lands along their banks as shown in the plan of the Khleang inscription K. 542 (928 *śaka*; *IC* III: 223). Finally, mentions of *travāṅ* indicate that they were often donated to sanctuaries and implicated in commercial transactions. The inscriptions then commemorate their excavation, their price or the donation.

Inscription K. 342 makes an interesting and significant mention of *travāṅ/trapeang* (l. 4; 930 *śaka*; *IC* VI: 236). In this text, among the rich donations, including vases and cult objects made of precious materials, a piece of land is offered accompanied by a *trapeang* interestingly named *sajjanataṭāka.* It is difficult to say here whether this name intended to signal its sacredness or its vast dimensions, but the first interpretation seems most likely.

The question remains: are these hydraulic structures religious or profane? The right answer is both. Sometimes the profane function is obvious, as in the 11th c. inscription K. 617, l. 8, in which the digging of a trapeang (*jyak travāṅ*) is mentioned alongside plantations of areca trees, and other cultigens. In contrast, when assigned to sanctuaries, they were also places dedicated to ritual ablutions. The inscription K. 235 of Sdok Kak Thom for example clearly specifies the infrastructure built accompanying the foundation of a temple, and it proves difficult to separate sacred and profane in such cases:

ta sruk bhadrapattana sthāpanā vraḥ liṅga I pratimā 2 dai ti leṅ nai santāna 'oy sarvvadravya ta vraḥ noḥ phoṅ 'oy khñuṁ coṅ valabhi coṅ kaṁveṅ 'leṅ thve kṣetrārāma jyak travāṅ thve daṁnap

"In *sruk Bhadrapaṭṭana*, [he] set up one holy *liṅga* [and] two images which were not family property, gave them all manner of costly things to those sanctuaries, gave slaves, erected a

3 *Travāṅ ~ travaṅ ~ trāvaṅ* "Body of standing water: pond, pool. 2 n. Reservoir, tank", Jenner 2009, *s.v.*

valabhi, built a laterite enclosure, made field and garden, dug a reservoir [and] built a dam." (K. 235D, l. 47-48; 974 *śaka*; Chhany Sak-Humphry 2005, p. 145).

This duality of function is well summarised in this extract from the foundation inscriptions of the eastern baray where it is compared to the Ganges, an important place for ablution, but which also specifies that it allowed the irrigation of tree plantations:

"It is by this master of kings that this *taṭāka* was dug, whose banks are planted with trees covered with flowers, which is like the celestial river of the head of Tripurāntaka".

"And he who walks at the head of those who give implores again and again all the kings of the kings of the Kambuja, those of the future: You must protect this which is the bridge of your own dharma, …"

"Thinking of me, let not these guardians of the *taṭāka* be taken away and let no harm be done to them..."

"These baby-calves, the young trees which the earth makes grow with the waters born of the womb that is this *taṭāka*, whose soft mooing is not perceived as a child's wailing, protect them intact from the serpent that is evil, …"

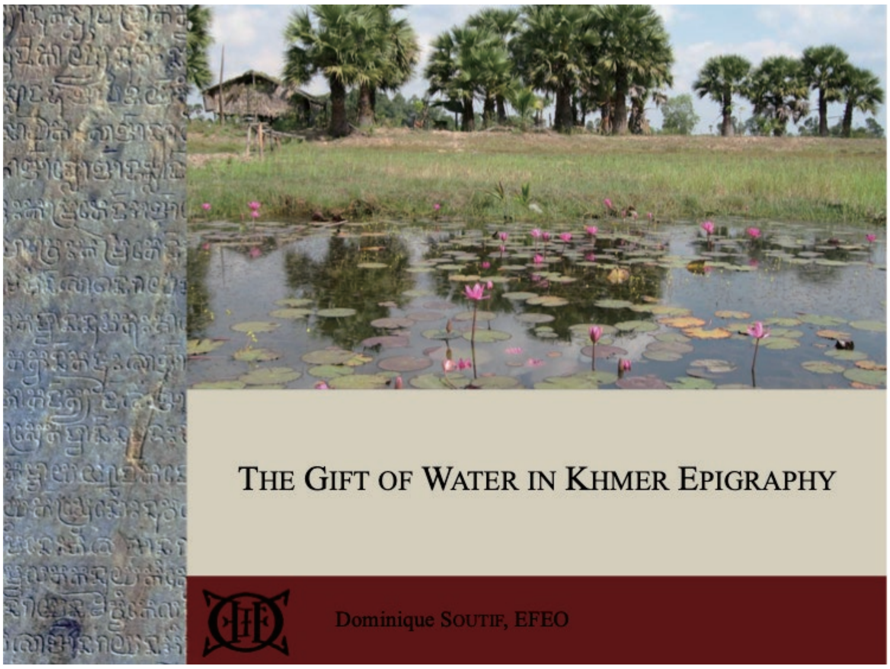
"Those who, the best of givers, willingly give even authentic jewels to those who beg them, those you are, how could they not grant me here only water?"

"And it is well known that supplication is death, especially that of a king; nevertheless, let it be' For death for the sake of dharma is recommended to good people; therefore, O generous one, I beg you'."

(K 280, stanzas CIII to CVIII.)

Thus, we can confirm the expected omnipresence of the mention of hydraulic works intended for both agriculture as well as ritual in inscriptions of ancient Cambodia. The very fact that references are far more numerous in ancient Khmer texts than in versified Sanskrit inscriptions praising the ruler attests once again to the fact that unless admirable and monumental, they were far too commonplace and taken for granted to be celebrated in royal eulogies. However, they were clearly the subject of attention in more administrative texts.

The fact remains that the location and the precise characteristics of these structures are often imprecise and only rarely make it possible to determine their role and the importance they assumed in a given sanctuary. We can, however, hope that in the long term, especially when these basins are used to specify the location of a land, certain case studies will allow us to better understand the Angkorian landscape as well as the life and functioning of certain settlements.

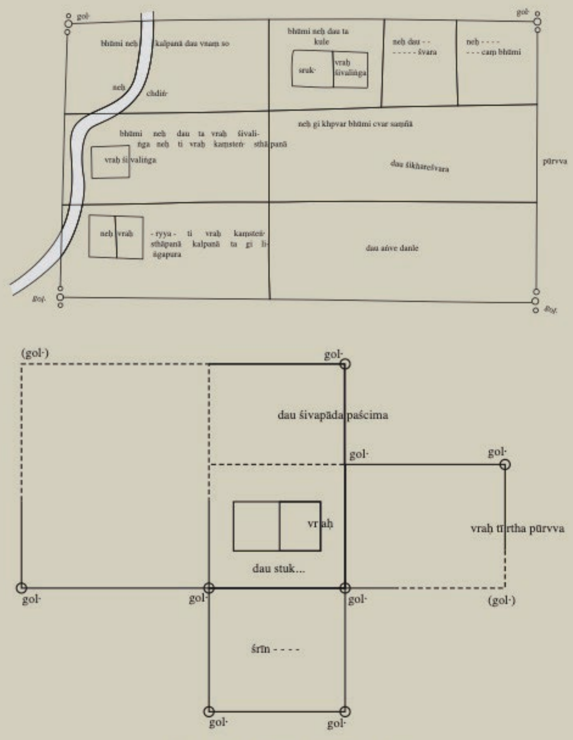


Extraction of corundum by sieving in the Pailin region (D. Soutif)

K. 299.14, Angkor Vat 12th c.

⊙ *'asthibhaṅga ∘ 'nak ta kap· ypar· padaḥ travāṅa 'añcan· 'antvaṅ· sabhāsthāna phoṅ· ∘ 'nak ta paṁpat· tīrtta 'nak· ∘ vidharmma*

"Asthibhaṅga, "Bone breaking": People who, contrary to the Law, destroy with weapons gardens, houses, ponds, moats, wells, public buildings; people who destroy the *tirtha* of others."



K. 542, map ; 928 *śaka*

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Angkor Hydraulic City and its Water Management

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1. Introduction

Cambodia is located in Southeast Asia and has a surface area of 181,035 km^2, about half the size of Japan. The Cambodian population is around 17.5 million (estimated in July 2023). It is important to emphasize that the history of our nation began with water and has remained interwoven ever since. According to Khmer mythology, in the 1st century an Indian prince, named Kaundinya (Preah Thong), traveled by boat to a small island and married a Khmer queen named Soma (Neang Neak, or Nagi), the daughter of the king of the Nagas. The Naga were a pan-Asian, mythical race of reptilian beings, who possessed a large kingdom in the Pacific Ocean region.

In the presence of the Khmer wedding, we still recall the gesture of the Groom taking the veil of the Bride to enter the ocean. The Naga King, the father of Queen Soma, drank all the water that inundated the land and gave it to the newlyweds as a dowry, which later became known as Cambodia. Cambodians today still say that they are "***Born from the Naga***", meaning from ***water***.

The ancient Khmer people were a traditional agricultural community, dependent on rice farming. The Khmer farmers planted rice near the bank of the lakes or rivers, in the irrigated plains surrounding their villages, or in the hills when lowlands were flooded. The rice paddies were irrigated by an extensive and complex hydraulic system, including networks of canals and large reservoirs called 'Baray', which allowed 3 harvests per year. This civilization which was founded and depended on water, entered into a period of great prosperity and established the Khmer Empire, from the 8th to 14th centuries, where many temples had been built, including Angkor Wat and its extensive water network. The geography of water has always played a significant role in the country - it is everywhere and in abundance.

In modern-day society, water remains the very soul of Khmer life. In many religious rituals, water is used as a sacred beneficial element: in the Royal Palace; in weddings, funerals, and services of blessing. The annual Water Festival is an important event for millions of Khmer people.

The Angkor Ancient Hydraulic System was constructed during the golden age of the Khmer Empire, as the vital element for the cohabitation between temples, nature, and people. This ancient water system is in place today and is the subject of our study and presentation to understand how it functioned.

The research demonstrates that Oc Eo (O Keo, in the south of Vietnam) was the first Khmer capital in the 1st century and it has a connection canal of around 80 Kilometers to the second capital in Angkor Borei (in the 3rd century). This second capital has its hydraulic system important to the defense of the city itself. The third is Sambo Prei kuk which was been the beginning of a large-scale water system for the city and it was later a model for the Angkor hydraulic system.

Birdseye view or from a Satellite image of the Angkor region, we can see the hydraulic structures such as ancient canals, dikes, and ancient reservoirs (Barays). If we compare only inside the Angkor World Heritage Site area, we found that water bodies represent more than 18% and temples only 3.48% of the total area of Angkor Park 401 square kilometers.

Khmer ancestors gave a very important role to water we can find evidence of not only tangible heritage, through the remaining construction of hydraulic structures but also intangible heritage like ceremonies in the daily life of local people in the village or the Royal Palace as well as in historical record by an inscription at Preah Ko (K 713). This inscription mentioned the priority mission of King Indravarman I starting to set up a hydraulic work called Indratataka (ancient reservoir Lolei) within 5 days after he became King in the year 877. The remains of the hydraulic civilization are represented by important water-works still very visible on the ground giving us an idea to understand how the theory and application of the Angkor Hydraulic System had been built and worked.

The statement of inscription of Angkor in the UNESCO World Heritage List, in 1992, mentioned clearly in its Outstanding Universal Value (OUV) the importance of water infrastructures “Angkor consists of scores of temples, **hydraulic structures (basins, dykes, reservoirs, and canals)** as well as communication routes”. Angkor represents one of the most ancient hydraulic civilizations in the world. Otherwise, we can understand the importance of Hydraulic work in the Khmer Empire; it became a tradition for the King to build a giant reservoir called “Baray” during their reigns. Again, as stated in OUV, dykes, and canals are still very visible on the ground today and at the same time, the roads are also the part of hydraulic system to manage the flow in the region since ancient times.

In 2004 to the preservation of the elements the most important of Angkor mentioned in the statement of the nomination dossier, the government of Cambodia created a new department of Water and Forest in APSARA National Authority in order to do research and rehabilitate the water system to be functional and safeguard the authenticity of Angkor as well as to assure the sustainable development in the region. The Department of Water and Forestry hasn’t been led by a simple administrator, but highly knowledgeable Khmer researchers in water. It is important to note that many Angkorian water works are still functional since they have been restored and made functional in the last nineteen years (from 2004) from my research results and implementation of technical design under my supervision.

This article will demonstrate how and why Angkor temples need a very large hydraulic system in Angkor City and also how it functions. This perfect concept and invention can continue to solve the problem that our world today faces with the problem of climate change. The last decade after the rehabilitation of this ancient hydraulic system demonstrated its effectiveness.

Notes:

- *We mention in this article 'Water and Forest Department from 2004 to 2008 and Water Management Department from 2009 to 2021.*
- *This article is updated from two main articles:*
  1. *Water and heritage in Angkor, Cambodia, The monuments, the ancient hydraulic network and their recent rehabilitation (Hang P., 2015)*
  2. *La gestion de l'eau dans Angkor, Capitale de l'Empire Khmer (Hang P., 2014).*

2. Angkor Cultural Landscape

Here we have several views of Angkor Park, onsite (in front of temples) or from space (from satellite images and aerial photos) which is composed of three elements essential: temple, water, and forest. It is important to note that these three elements are interdependent. Monuments and forests cannot exist without proper water management. These three together form the nucleus or the soul of the Ancient Khmer Civilization. These three main elements continue to live in Khmer culture up to today. In Angkor we can not only place for admire of perfect the combination of finesse architecture in temple carving and water around the temple but also the big trees with a variety of 154 species (Hang, 2005); and the immense water network and storage that has been built since the 9th century.

Khmer ancestors used water and trees not only for landscape management but they use for other purposes too that we can resume in a few words by technical explanation:

- The water is an element very important for the stability of the temples which will be descript further in the next chapters, and water is also an element of decoration and increasing humidity to reduce the temperature on the temple stones and its surrounding. Canals, ponds, dikes (to collect water and orient it), ancient reservoirs (Baray, basins) play the role of absorbing the flows during the rainy season very quickly (perfect natural water system to manage flood and drought), and transportation infrastructure (canals and dike as roads).
- The forest (trees) is playing the role to reduce evaporation from soil which reduces the loss of underground water (which links to the stability of the temple), increases the humidity in the atmosphere (by evapotranspiration from trees) that can reduce decay of stones, and to absorb the strong wind speed that can destroy the temple too.

Today (from 2020) in the world, many developed countries are using a sponge city (that call green infrastructure or low impact development or natural-based solution) to improve their water management system in the city such as flood, irrigation, water storage and climate change challenge. This concept is used by ancient Khmer wisdom. This article will allow us to understand and know how it worked in the past and how it can solve the problems today (climate change) through the ancient water management vision of our Khmer ancestors.

Figure 2.1:. Neak Peaon temple with water and forest surrounding

Figure 2.2: Angkor Wat temple with moats (water) and forest surrounding

In general, on map or on satellite images (Google Earth) can see Baray such as Western Baray, Northern Baray, Eastern Baray, Lolei Baray, basins, moats of Angkor Wat and Angkor Thom, canals, rivers, and ancient ponds. The water networks of Angkor Park are an amazing feat of engineering from this former civilization. The water network had many functions: within Angkor Park, the water provided religious and cultural as well as protection, transport, and for daily life.

Figure 2.3: Sacred water at Thousand Lingas in Kulen Mountain
(upstream of water sources)

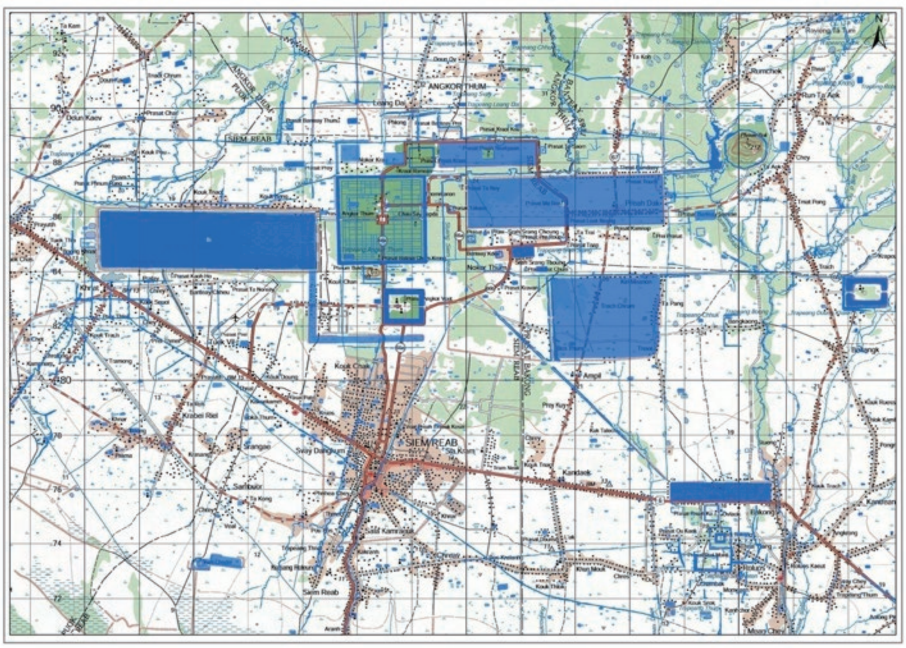

Figure 2.4: Map illustrates the location of ancient water reservoirs compared to
Siem Reap city

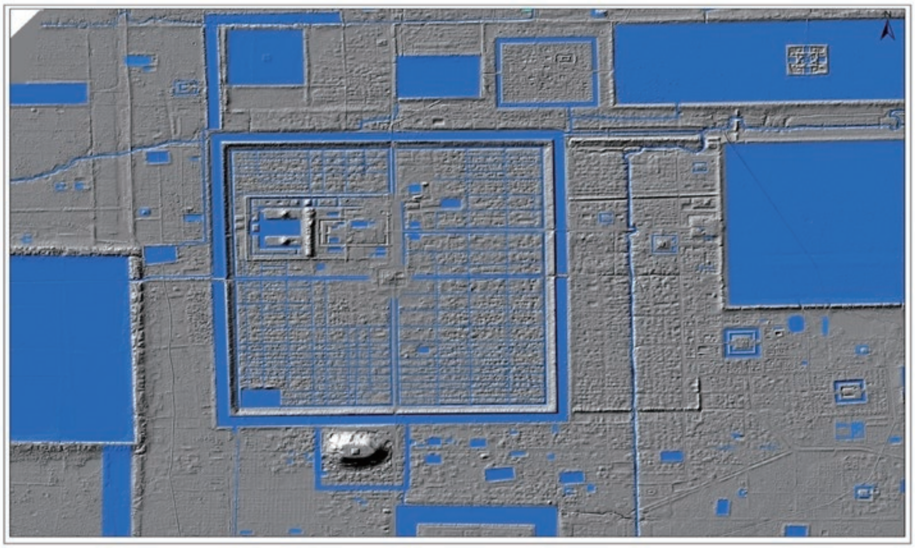

Figure 2.5: LiDAR map with highlight on water networks and reservoirs

The new technology—LiDAR (Light Detection and Ranging) has helped us to understand the vast scale of water network in and around Angkor Park (see Figure 2.5). The ancient reservoirs, connecting canals, and dikes are clearly visible.

3. Understanding Angkor Hydraulic System

3.1. Conception of Temple's Foundation

The soil in the central plain of Cambodia cannot support heavy loads. In order to build stone temples like Angkor Wat, Bayon, Ta Prohm, and Preah Khan, the best technique had to be found. All Khmer temples are built by putting stone one on the other without steel or concrete to tie between them, the foundation should be very good to assure them in place without any movement. At the time, Khmer engineers discovered the physical properties of sand and water and realized that they could combine these two elements for building: once sand wet can support a heavy load. The discovery of this technique led them to locate the places where this theory could be applied. Studies have shown that the Angkor region is the best location, as underground water is close to the ground surface. They then used the immediate presence of underground water to humidify the sand layer under the monument to ensure its stability. To assure the sustainable of ground water to support the temples, the Khmer ancestor introduces the water in its culture that we demonstrate in actual remain applications on the ground like the case of "thousands of Lingas and Moat". The ancient Khmers knew the vital role played by water resources in the safeguarding of the Angkor region and learned how to preserve water. This is why this vital resource is celebrated within the tradition, culture, and spirit of the Khmer people. Some of these customs are still celebrated today without talking about the other religious ceremonies practiced by local people every day.

The design of the temple with the moat surrounding is based on the Hindu philosophy of Earth and Water. Regarding the construction, the first task was to excavate the natural soil and replace it with sand. It was on this sand foundation that the temples were built (see Figure 3.1). The temple moat is responsible for maintaining the drainage system by first receiving and storing excess rainwater and second supplying water to the sand foundation to sustain its stability (see Figure 3.2.2).

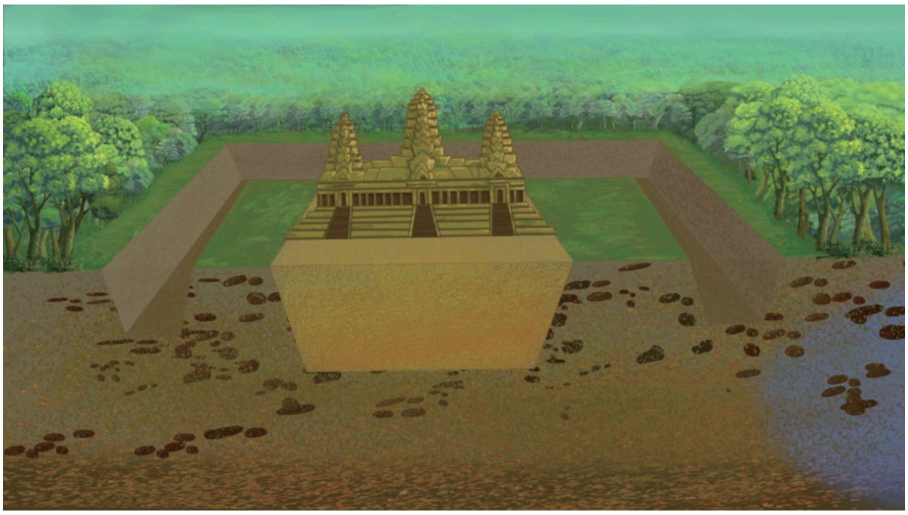

Figure 3.1: Conception of Angkor temple's foundation

3.2. Knowledge Transfer on Hydraulic System

3.2.1. The Sacred Water of the Mount Kulen

Khmer ancestors carved the Siem Reap River of Thousand Lingas in the river beds of Mount Kulen and Kbal Spean (figure 3.2.1.1), where these rivers source before they flow into Siem Reap and the Angkor site plain. At Banteay Srei, they flow together to form the Pouk River later in the 9th century this part of the watercourse was been modified at Bampenh Reach to create an ancient canal that we call today the Siem Reap River. The water flowing from the "Thousand Lingas" has become sacred and has been used in the major ceremonies (e.g. coronations, and cremation ceremonies) of the Khmer Kingdom since the 9th century. During the coronation, the sacred water of Mount Kulen is used to bless the future King. This tradition is still practiced like during the coronation of actual king H.M. Norodom Sihamoni in October 2004 (see Figure 3.2.1.2), it used sacred water from Kulen Mountain (http://news.bbc.co.uk/2/hi/asia-pacific/3963945.stm). The Khmer population believes in the power of this sacred water, using it to cure diseases or during blessings to bring luck. Again, we would like to stress its meaning: Why do Khmer ancestors oblige not only local people to respect the sources of Kulen water by introducing it in the highest ceremony of the Khmer Kingdom? But the real goal of the sacred water from Mount Kulen is to underline to the population the need to protect water resources, and the region's life-blood, and to maintain the sustainability of this resource, which is essential for the conservation and development of the Siem Reap region. Therefore, the water source of Kulen Mountain will be lost if deforestation continues and the environment is destroyed.

Figure 3.2.1.1: Sacred water - Thousand Lingas in Kbal Spean (same on other side of Kulen mountain chain)

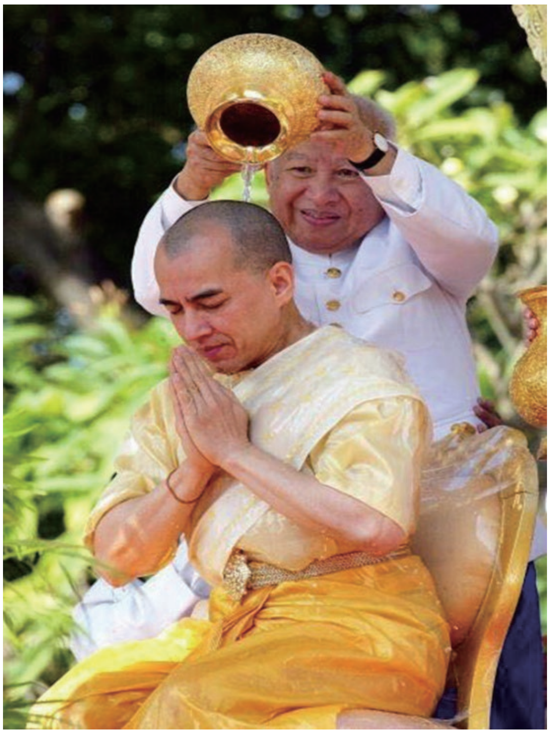

Figure 3.2.1.2: Coronation ceremony in October 2004
Sacred water from Kulen Mountain

3.2.2. The Moats

The moat surrounding our temple plays a pivotal role: it collects runoff water from the temple to avoid flood in the temple during the rainy season and recharges underground water to humidify the sand layer underneath the temple (see Figure 3.2.2).

The Khmer ancestors understood that if the safeguarding of water was conveyed as a message or ordered (law) by using technical reasons, this would not be sustainable. Therefore, by including the water as both a form of life-blood and as the basis for a system of beliefs, the recommendations may have lasted. Then to assure the sustainable water in the moat to support the temple, the engineering approach was transformed into the religious. The moats are considered in the Khmer tradition as the Ocean and the temple as Mount Meru (the dwelling of the Gods).

To prevent the decreasing of underground water level like to the rainfall and recharge, they introduced the backup system since the beginning of temple construction is the moat surrounding the monument. This moat system is ever built for defense system like in Europe or others culture.

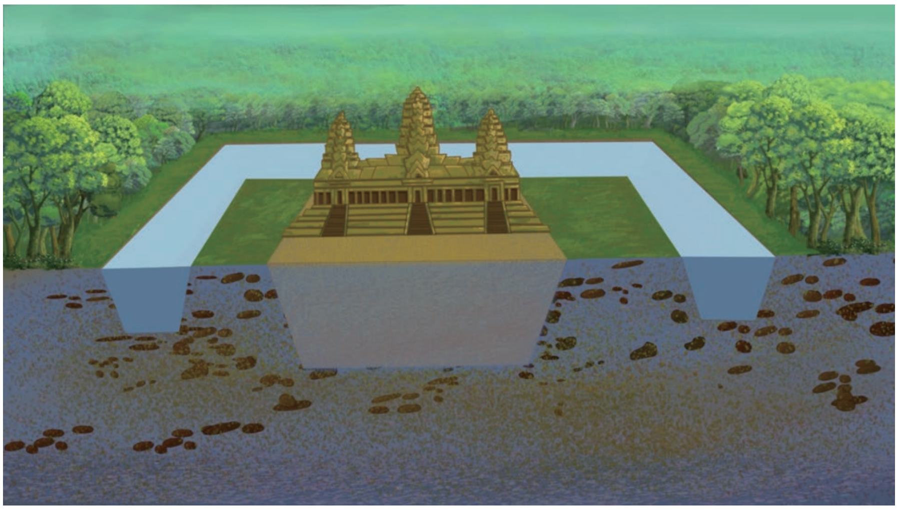

Figure 3.2.2: Moat and the underground foundation of temples

3.2.3. The Angkor Hydraulic System

Even though Khmer have had water knowledge in their blood since begin of the 1^{st} century, the Khmer ancestors have to find ways how they can make future generations understand the important Angkor Hydraulic System with simple explanations and can illustrate onsite for easy understanding. One example is that they left for future generations to learn how they keep all decorations like the Apsara dancer's status on the walls of Angkor Wat and Bayon and other temples.

In the 12^{th} century, the Khmer reached to develop very high technology on water at a very large scale, and also very complicated to understand its functions. The same technical for teaching the next generation about the hydraulic system by using North Baray (Jayatataka built in the 12^{th} century by King Jayavarman VII) which links to other two temples that demonstrate clearly how the Khmer hydraulic system can function properly with the natural concept of gravity flow from one place to another by allowing us to understand even if we are not specialist of water. The illustration of this system can be demonstrated to the public by North Baray, Neak Peaon Temple, and Preah Khan temple (see Figure 3.2.3.1 and figure 3.2.3.2).

The North Baray has its Mebon (temple in the middle of an ancient reservoir) called Neak Peaon built as an island of 385 meters by 345 meters in which the five basins were built on the island to be demonstrated communication flow underground (infiltration into/out soil) from North Baray to five basins and Preah Khan moats:

1. the underground flow without pipes from Baray to central basins by using the principle of “communicating vessels” to balance the water level inside basins and outside (in Baray). Five basins are full of water by infiltration from Baray (see Figure 3.2.3.1).

2. the underground connection of the moat of Preah Khan temple with North Baray: the difference water level of both water bodies allows the underground flow quickly (water level in Baray is very high compare to water level in moat of Preah Khan) see Figure 3.2.3.2. Preah Khan moat doesn’t have a system or canal to bring water. Before our achievement to rehabilitate North Baray, these moats were dry in the dry season.

3. the surface system is the gravity flow that can assure more than 100 billion liters of water capacity moving from one place to their destination. Note that the general topography of the region is northeast high and southwest low, in natural ground the slope from north-east to south-west is one meter for one kilometer of distance.

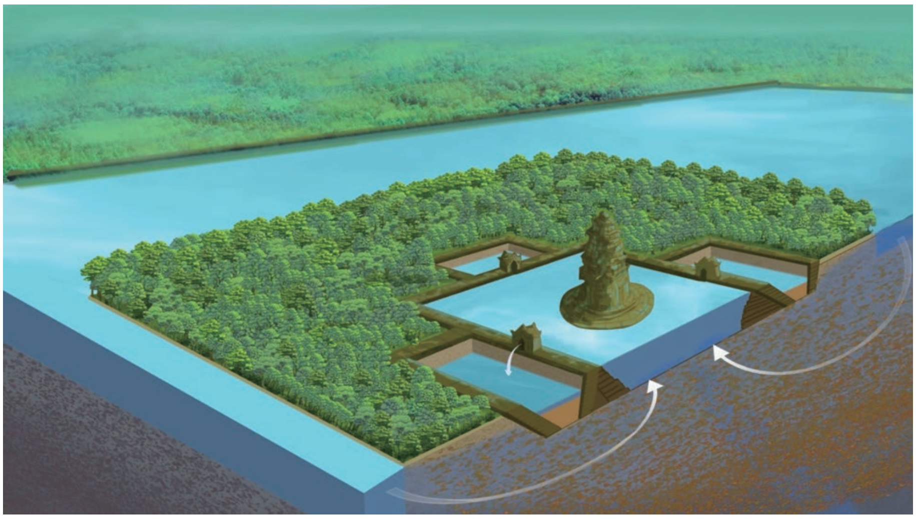

Figure 3.2.3.1: Understanding the underground flow: Neak Peaon case study

The both point 1 and 2 (figure 3.2.3.1 and Figure 3.2.3.2) allow us to understand very well how the underground flow can help to assure the stability of the temples in the region. The point 3 can give an overview of the whole water surface system of Angkor (see Figure 2.4), how it works, and how it can bring one to other storages in the region especially for Baray, moats, canals, and ponds.

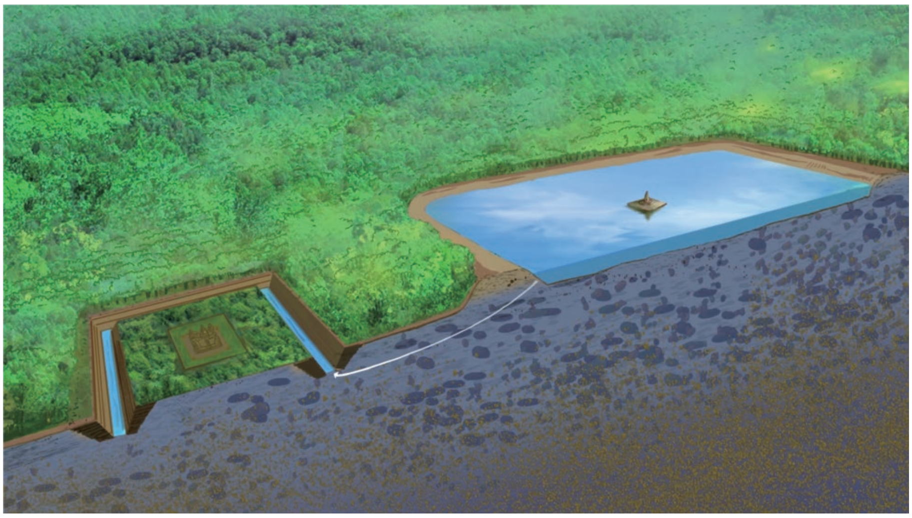

Figure 3.2.3.2: Understanding the underground flow from the upstream reservoir to other temples

4. Issue of Development of Siem Reap City

After the inscription of Angkor in the World Heritage List in 1992, Siem Reap city continued to be a small city until 1995 when the water supply could be taken from Siem Reap River (nearby Royal residence). From 1995 to 2005, we changed the source of water for the water supply of the city from surface water (Siem Reap River) to underground water because the flow capacity in the dry season (November to April) is very low with very high demand in the city. We are pumping with a capacity of 1,440 cubic meters per day.

Because of the increasing number of visitors (local and international tourists), the demand for water supply continues to increase every year. Following the JICA computation in 2009, the city needs 27,900 cubic meters in 2015 and 83,300 cubic meters in 2030. In reality, in 2015 we need more than 30,000 cubic meters per day with some local people's wells. We would like to note that the Siem Reap Water Supply author can supply to pump from wells in South of West Baray and water from West Baray (the ancient reservoir built in the 11th century), but it can cover only 47% (in 2022) and remain continue to use underground water by privates' wells.

To understand the underground water layers and how they react when much water pumping in the city of Siem Reap and the ancient reservoir can respond to this problem, APSARA National Authority did the pumping test. To avoid any problems in the temple area, we decided to do it for three weeks from 11 to 29 July 2008. Two wells are located near Angkor Wat moat and one is near the Royal residence (Siem Reap Water Supply Authority office a few meters from Siem Reap river). Technical aspect to take in to account is:

- During the rainy season to ensure quick recharge with the effect of the rain on underground recharge,
- The pumping well is close to Siem Reap River and easy to recharge (Siem Reap River is full of water),
- Monitoring well nearby Angkor Wat to see the reaction of the recharge from the moat.

The result from graphic Figure 4.1 and Figure 4.2 will be analyzed as follow:

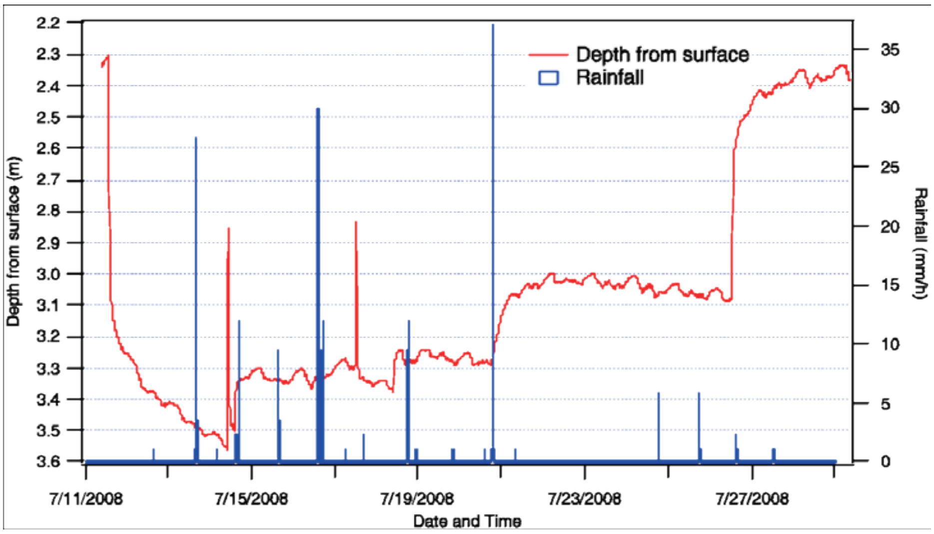

Figure 4.1: Pumping well at Siem Reap Water Supply Authority office
(near Royal residence)

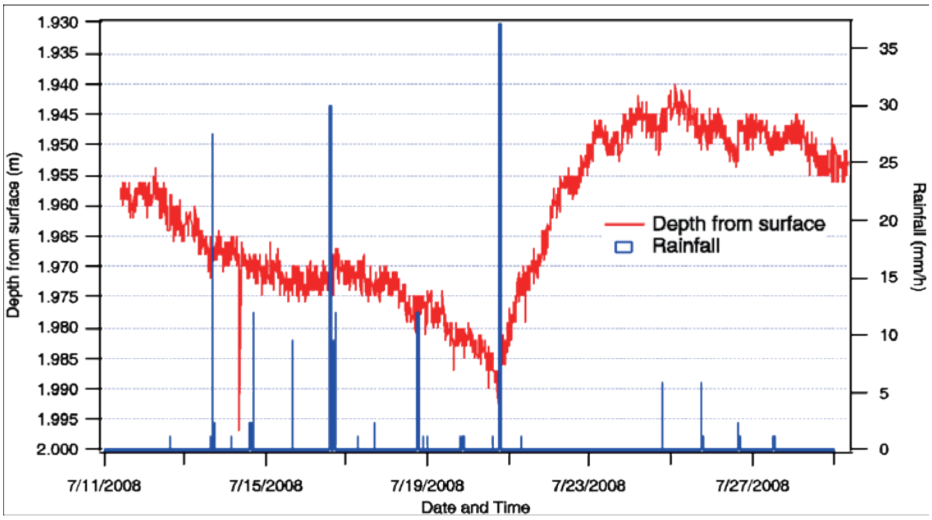

Figure 4.2: Pumping well at South-west Angkor Wat (close to Angkor Wat moat)

Figure 4.1 and Figure 4.2 allow us to understand the effect of pumping a well with high capacity, the water table dropped immediately when pumping started for the well at the city center but the well in front of Angkor Wat dropped a few days later. We observed as well the light rain didn't increase any increasing water table during our test, but the heavy rain effect immediately to Angkor Wat well, not the case in the city area, it affected a few days later. Note that the two high peaks increase in a short time in Figure 4.1 is electricity cut off, it's not rainfall effect or another recharge.

In conclusion, the pumping test even during the rainy season, and both wells are very close to water bodies (moat and rivers), the result demonstrated that the extraction of underground water in the city center has affected the underground water level in upstream (temples area).

The revenue from tourism represents around 16 percent of GDP before Covid-19. Therefore, we can't stop the development in Siem Reap city where are the infrastructure and services of tourism in the region in which the water demand is increasing every year. We need to note that Angkor is considered as an attraction of tourism to Cambodia. Therefore, we have to find a compromise between Conservation and Development in Siem Reap region. APSARA National Authority has to ensure this very important role.

5. Solution of APSARA National Authority

The research demonstrates the importance of underground water to assure the stability of temples. The government of Cambodia understands well the issue that can cause heritage destruction but we need to assure as well the water supply to living people and visitors in and around Siem Reap city, the master plan for the development of water supply has been studied but all this kind of investment will take a lot of time, so the quick, sure and less budget to do and also to be in favor of the conservation of heritage is to rehabilitate the ancient reservoirs in Angkor Region. Therefore, it's why the government of Cambodia decided to allow the APSARA National Authority to create a new Department of Water and Forest in 2004 to do the research and apply how we can face issues caused by development in Siem Reap/Angkor region.

The intensive research on the history of the water system in Angkor gives us a very good understanding of the long-term vision of the Khmer ancestors on conservation and sustainable development. Based on these results APSARA National Authority proposed to rehabilitate the ancient reservoirs to respond immediately to problems caused by extraction of underground water in the region.

5.1. The Lolei Baray (Indratataka)

The reason why Baray of Lolei has come first in this article even though it isn't completely in full function like other ancient reservoirs, is because we wish to remind the importance of the first giant work on water management structure ever built and setup as first model and priority in this kingdom.

The city of Roluos (Hariharalaya) is almost entirely a creation of Indravarman I's decade-long reign. Norms that were established at this site were followed by architects and urban planners throughout the Classic Angkor period. Indravarman I's most astonishing feat, begun five days after his coronation rite, was the construction of an immense rectangular water reservoir or Baray known as the Indratataka, or the Lake of Indra. (Michael D. Coe., 2003).

In fact, King Indravarman I has left some very interesting inscriptions that tell us in clear terms the direct, personal commitment of Angkorean kings to patronize water works to boost agricultural production at the scale of the empire. Preah Ko is a temple at the ancient site of Hariharalaya (Roluos), some fifteen kilometers away from the present city of Siem Reap. The site functioned as the capital city before the succeeding King Yashovarman I transferred the capital to

Yasodharapura (Angkor). The Preah Ko inscription dated 877 AD (stanza 7) says that, on the day King Indravarman I obtained the kingdom, he made the following solemn promise to himself (George Cœdès, 1927):

"In five days, beginning from today I will commence to dig…"

"prathamamlabdharājyo yah pratijnākritavāniti
itaḥpancadinādurdhvamprārapasyekhananādikam. (stanza 7)

Indratataka, is a rectangular body of water, with its long axis east-west, just to the north of the Bakong. It was doubtless designed to hold a reserve supply of water for the use of the city and its temples and the irrigation of the surrounding rice-fields—probably the first of the irrigation works in the beginning of the Angkor Empire (Lawrence Palmer Briggs, 1999).

Yasovarman I's first important work was "finally completely enclosing huge artificial Indratataka, and constructing a large ancestral temple, Lolei, on an island (Mébon) in the middle of this huge artificial lake. It is interesting to note that inscriptions were inscribed on the sandstone doorjambs of Lolei temple. ***These inscriptions are permanent records of the importance of water works in the development of Angkor civilization.***

This Baray Lolei has rehabilitated the original inlet in the North-east in 2015 with the APSARA National Authority budget. The intake water from Rolous River (North of the inlet of Baray) and outlet structures in the South-west corner of Baray on National Road N6 in 2017-2018 with budget ACHA project - cooperation project between APSARA National Authority and Ministry of Foreign Affair and Trade (MFAT) of New Zealand. After this rehabilitation, we can say the Baray Lolei's hydraulic structures are ready to assure their function as ancient times, but we are still to remove a modern road across the Baray and relocate some of the local people who live inside this reservoir. Even with this difficulty, the Baray already played some roles in reducing floods in the Rolous region by storing temporary floods since 2017 each year. Recently in August 2022, Baray Lolei can store around 70% of its maximum capacity of 3 billion liters.

Figure 5.1: View on Baray Lolei from West Dike

When this Baray will be in complete function, the moats of Preah Ko and Bakong (outside moats too) will be full of water for a whole year and the flood in Rolous (downstream of Baray Lolei) will be under our control.

5.2. The West Baray

The West Baray was built in the 11th century and it is located to the southwest of the capital city of Angkor. This vast lake, 2200 meters by 8000 meters in extent, runs in the east-west direction. The southern dike of this lake buried, at its western end, the pyramid temple of Ak Yum (Bruguier, 1994) under the huge pile of the earth, from which it was brought out by George Trouvé. The West Baray can store more than 56 billion liters. The main role of this Baray is to recharge the groundwater and to assure the irrigation with their canals in the south-west.

Based on the design of French specialists (see Figure 5.2.1), to bring water back to West Baray, in 1957, it needs to dig a canal and build spillways to allow the water to flow from Siem Reap River at the North-East corner of Angkor Thom, the canal passed inside of the Angkor Thom moat (North and North-West moat) about 4.5 Kilometers and connect to a canal parallel the access road of Takave gate (Western gate) of Angkor Thom (map of this system was published in the article of Goloubew in 1941), this work can't reach the maximum storage capacity. These canals caused this part of the Angkor Thom moat out of water and the Eastern part of West Baray too; then some researchers believed that Eastern part out of water was caused by sedimentation. Note that is not designed by a water specialist with depth research on its water system.

In 2010, the Water Management Department of APSARA Authority discovered the Original feeding system of West Baray in which one ancient pound called 'Tropeang Khchorng' (de-sedimentation basin located at the North-East corner of Baray) and the ancient canal (North to

South direction) come from North-West corner of Angkor Thom moat. In 2011, APSARA reopened the original inlet canal of West Baray to absorb the flood to protect the villages (see Figure 5.2.3).

In 2012, APSARA rehabilitation the whole feeding system that is able to feed the West Baray in the short time with original capacity of 56 billion liters. Nowadays the West Baray is connected to flood management system that described in chapter 6.

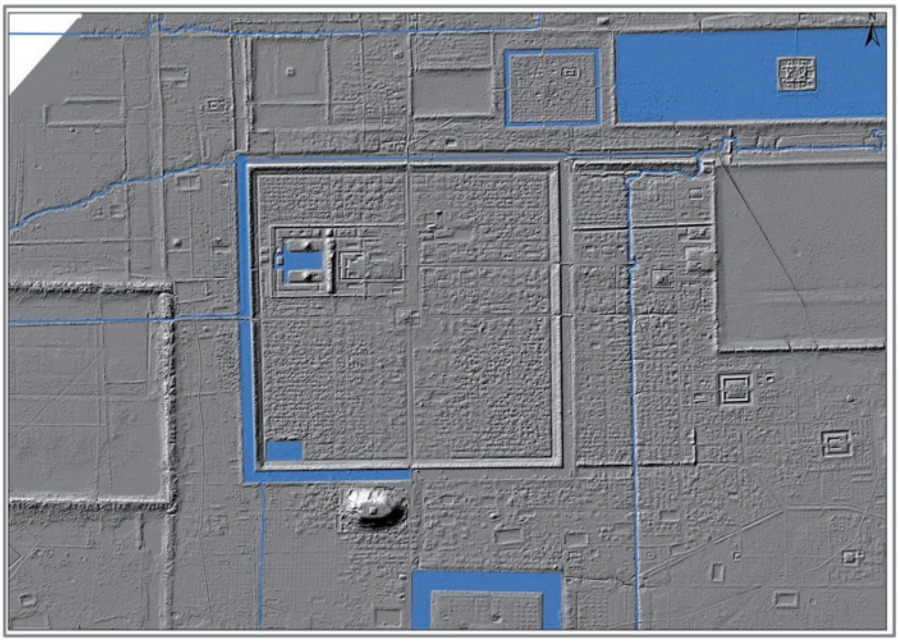

Figure 5.2.1: New canals dug in the Angkor Thom moats to bring water from Siem Reap River to West Baray (one-third of West Baray was dry even in the rainy season)

Figure 5.2.2: View from South-west corner of West Baray (full of water)

In 2013, because of flood caused by a typhoon in the region, the storage of Baray was been 65 billion liters with a maximum of storage 56 milliard liters. To prevent damage to the ancient dike of the 11th century, APSARA National Authority decided to rehabilitate the ancient spillway at south-west corner of Baray. The work was been conducted in very critical situations, day and night. Without anticipated research findings, the dike could be destroyed and thousands life of people in downstream could have been in danger. See some photos to illustrate these works (Figure 5.2.3 and 5.2.4).

Figure 5.2.3: Urgent intervention at Ancient Spillway during the flood 2013 to reduce water pressure on West Baray dikes to save heritage (Baray) and local people's life in southern of Baray

Figure 5.2.4: Setup spillways to assure quick flow from West Baray (from 65 to 56 billion liters)

5.3. The North Baray (Jayatataka)

It has dimensions of 3600 meters by 930 meters with a storage capacity of 5 billion liters for the first phase and for the second phase, it increases the storage up to 10 billion liters by raising the dikes. Jayatataka or North Baray was built in the 12th century (1181 AD) by King Jayavarman VII, it started drying up in the 16th century. This is a new invention of water engineering technology in the Khmer Empire of the 12th century; the North Baray is filled with water by a network of dikes and canals to collect runoff water and rise up water level to flow into Baray. The dike and canal system begin from the North-west dike of North Baray and turns four times in 90 degrees before going straight to the north till the foot of the Kulen chain. These large canals (60 meters wide) are used by local people as rice fields because no water flows through more than 500 years ago and some villagers built their houses in this runoff water collection system of North Baray.

This feeding system of North Baray is very complicated to understand how this Baray was filled before our research in 2004-2005. The indication of the research with local people that the dikes that have been found on the site North of Jayatataka is called the 'Ancient Royal Road to the mountain', but from experience it can't be a royal road because:

- It turns 90 degrees four times – it's not the case in the 12th century road,
- It has only one canal along the dike – in ancient times even today in the plain area in Cambodia the road was built by excavating the soil from both sides to make the road and it became a drainage canal later. But these dikes have only a large canal and the other side is natural ground level.

These reasons lead to the conclusion that is the 'dikes and canal system to collect runoff water' for North Baray. All the Barays in the Angkor region have their inlet water at the North-east corner, but during the rehabilitation of North Baray, it is necessary to move the inlet structure to the connection point between the feeder system and the north dike. This choice avoids flooding the local people who live in the system of water collection for Baray. Also, the ancient canal is dredged (cleaned) only 20 meters instead of 60 meters to keep the rice field parcel of local people.

The restoration work was started after the approval of ICC-Angkor (The International Coordinating Committee for the Safeguarding and Development of the Historic Site of Angkor) in June 2007. The southern broken dike of Jayatataka at Kraing Kroch (East), original outlet near Preah Khan temple, and 13 points on the runoff water collection system were repaired. Then the Jayatataka collected 700 million liters for the first rainy season (in 2008), 2.98 billion liters in 2009, 3.678 billion liters in 2010, and more than 5 billion liters since 2011. The local community comes to catch fish in this Baray every day. APSARA National Authority is helping villagers of Phlong and Leangdai to set up community business on the 'Natural Circuit at North Baray' (Baray Reach Dak community tour) this allows them to have income from guiding tourism to visit the natural circuit around Baray and visiting flooding forest inside the Baray by local boat (Hang, 2014). This local community project has been duplicated to Banteay Srei, see detail in 5.5 below.

This Baray wasn't used for irrigation purposes like other Baray in the region, but it used to supply the Angkor Thom city, Preah Khan, and Neak Peaon functions based on water.

5.4. Srah Srang

Basin Royal was dug in the mid-10th century and modified in the 13th century by King Jayavarman VII. It has been dried in April 2004. This basin doesn't have a system to bring water, the sources of water come from the rain and groundwater that link to East Baray through underground and/or groundwater. As the East Baray dries up and the water table goes down, so the Srah Srang also dries up in the dry season. In March 2005, the Water and Forest Department set up a new system to fill Srah Srang by taking water from Phnom Bauk reservoir (Rolous River) through East Baray.

Figure 5.3: View on North Baray (Jayatataka) from East

Figure 5.4.1: View from Banteay Kdei temple on Srah Srang

5.5. Srah Srang

Basin Royal was dug in the mid-10th century and modified in the 13th century by King Jayavarman VII. It has been dried in April 2004. This basin doesn't have a system to bring water, the sources of water come from the rain and groundwater that link to East Baray through underground and/or groundwater. As the East Baray dries up and the water table goes down, so the Srah Srang also dries up in the dry season. In March 2005, the Water and Forest Department set up a new system to fill Srah Srang by taking water from Phnom Bauk reservoir (Rolous River) through East Baray.

5.6. Banteay Srei

Banteay Srei's moat and its small Baray (at the North-east of the temple) were rehabilitated in 2009 after the restoration of the temple by Switzerland. Like Preah Khan's moat, the Banteay Srei's moat was been dry during the dry season. Two water structures were built on the southern dike to assure the overflow from the Baray and the irrigation of rice fields in the south of Baray. That Baray is full of water the whole of the year that can supply to the moat of Banteay Srei via underground flow. After Baray has water full year, the local community can benefit from the presence of water for fishing and community tourism like boat tours in Baray. The APSARA-NZAid project (NZAid: New Zealand Agency for International Development) supports the local community to set up these activities. This community project was been inspired by the North Baray project.

5.7. Angkor Thom Moat

It's only 3 Kilometers of the South-West moat that has water, and the South-East Moat has water only during the rainy season. In 2010, the Water Management Department made an archeological survey at the Eastern part of Angkor Thom (Victory and Dead Gates) then connected the Eastern moats together (North and South moats). From this work, the South-East moat (3 Kilometers) has water for a full year (dry and rainy seasons). In 2012, with the restoration work that linked to the rehabilitation of West Baray and the ancient hydraulic network for optimization of water management, the whole moat of 12 Kilometers flooded. This moat can store nearly 2 billion liters of water.

Figure 5.6: Angkor Thom moat: view from South gate to East

5.8. Angkor Wat

In April 2004, the moat of Angkor Wat was been dry (see Figure 5.7) because the water in the moat was enough to ensure infiltration and evaporation and the second reason was the dry year (various places in Cambodia faced this phenomenon). The water in the moat was very shallow because the previous feeding system of Angkor Wat moat is an ancient canal from South-West moat of Angkor Thom with a canal behind the Balloon through Tropeng Ses (Western of the road in front of Angkor Wat). This system takes more than two weeks to bring water from the Siem Reap River to the Angkor Wat moat and it can't raise the water level in the moat as in ancient times. In 2010, the rehabilitation of Sampeou Loun canal and the Moat of Phnom Bakheng then connected to the South-East moat of Angkor Thom feed the Angkor Wat moat with maximum water level (see Figure 2.2) as ancient time in a short time. This system raise up water level in the moat to more than 1.3 meters higher than the maximum level of the previous feeder system.

Figure 5.7: Dry moat of Angkor Wat temple in April 2004 (a few months before the creation of the Water and Forest Department)

5.9. East Baray and other Ancient Reservoirs

In the year 2023, APSARA National Authority rehabilitates also the Tonle Snguot reservoir located west of Preah Khan (North of Angkor Thom) and Ta Promh moats (see Figure 5.8.3), an ancient pond of Bat Chum temple, an ancient pond at east of Srah Srang and East Baray.

For Yaśodharatataka or East Baray: We are in the progressed work of rehabilitation of East Baray built in the 9^{th} century by King Yaśovarman that can store about 36 billion liters of water. We planned at less to have half of Baray in water (around 9 billion liters) where we don't have local houses. We start our work with the restoration of dike and water gates. Two new small water gates (in the green color of Figure 5.8.1 and photos of activities of rehabilitation in Figure 5.8.2.) have been built to manage the storage water in the Baray for local people as well as for feeding the ancient reservoirs (moats, ponds, and Srah Srang) in downstream (south) of East Baray.

Outside of Angkor Park, we also restored the moats of Chao Srei Vibol temple, which have been filled with water since 2016. The moat of Beng Mealea and Baray has been rehabilitation; it starts to fill with water by this rainy season (2023) for the first time after a long time dry. The Beng Mealea Baray will help the local people to more water storage for their daily lives.

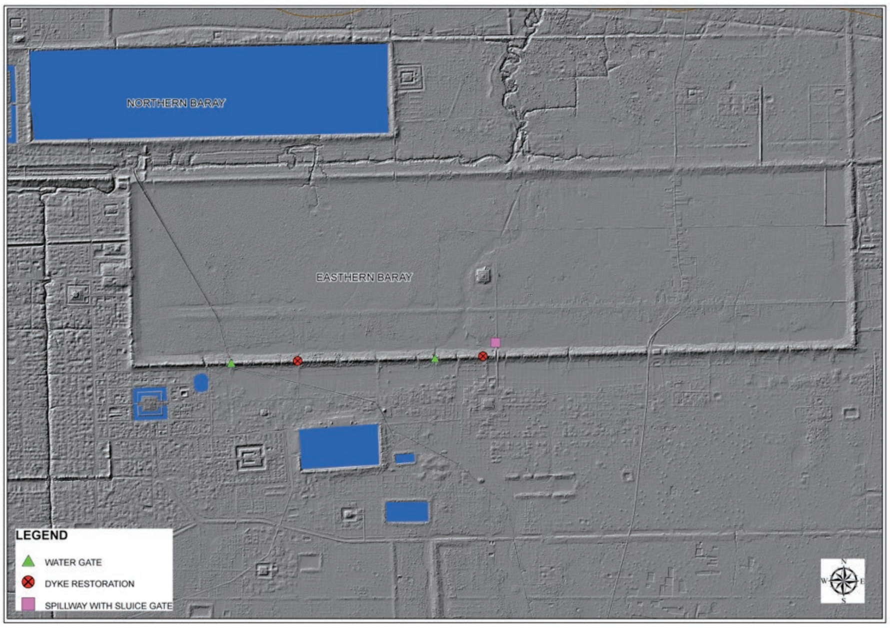

Figure 5.8.1: The restoration South dike of East Baray to bring back water like in the 9th century

Figure 5.8.2: One outlet water after restoration at South dike of East Baray

*Figure 5.8.3: Ta Promh Moats are full of wat*er in the rainy season of 2023

6. Floods in Siem Reap Region and its Management by APSARA National Authority

In the archives of the EFEO center in Siem Reap and the Documents center of the APSARA National Authority as well as in other archives including the inscriptions, we couldn't find any information relative to floods in Siem Reap Angkor region. Therefore, we try to dig out from the memory of the people, that many interviews with senior people in the villages were carried out between 2004 and 2010. In general, the important events that happened in Angkor should be transmitted from generation to generations, but nothing on the floods and droughts in Angkor were recorded. This information is very important for my research to understand the Angkor Hydraulic System.

Unfortunately, in 2009 we got flooded because of the Ketsana typhoon. This affected the entire region not only Cambodia. So Siem Reap city center is completely underwater, around Old Market there is a very high-water level even the pickup car can't drive across this part of city. The most important temples are threatened by the flood, especially Angkor Wat temple. The flow came out from Siem Reap river flows into the Angkor Wat's moat through north-east corner, this flow created quickly the big difference water level in the North and South moat of Angkor around 70 centimeters during two hours' time - it can cause to collapse of causeway of Angkor Wat if we allow more inflow to North moat (North and South moat was connected by a small pipe less than one meter diameter in 2009). To stop the flow from Siem Reap River into Angkor Wat's moat is very difficult because everywhere has stones as you see in the photos, we couldn't use machines to solve the problem, all done by human force (see Figure 6.2 and Figure 6.3).

In 2010, we also had a flood in Angkor and Siem Reap City, this had less impact on our temples but upstream of Angkor got a lot of damage, especially for local people north of Angkor

Park. We can say the flood of the year 2010 was under our control.

In 2011, there was a big flood in the whole region, which means Laos, Thailand, and Vietnam were also affected. Bangkok is completely under water. During these three years (2009, 2010 & 2011), the Angkor Park (all temples) area was protected from floods, but the Siem Reap city center was under water for a few weeks with each event of rain.

The point of view of hydraulics engineering is impossible the region where was been the city of the Khmer Empire for more than 500 years (9th and 16th century) is flooded. The Khmer ancestors knew how to bring water to the city, so they knew exactly how to manage floods and droughts. Therefore, let's see the solutions done by APSARA National Authority face to these problems.

The 12th century hydraulic system is the water network located in the Northern of Angkor Thom, Preah Khan, Ta Som temple. This system is a combination of the natural rivers (Pourk River, Rolous, and Stung Preah Srok River), canals (including Siem Reap River) dikes that linked between waterways and the ancient reservoirs (as described in the previous chapter). These networks are able to allow water engineering to optimize the whole water management in the Angkor region (see Figure 6.1, Figure 6.4, and 6.5).

In 2012, the government requested to APSARA National Authority to find out the solution to protect not only the temples in Angkor Park and upstream but also the Siem Reap city from flood. As showing in this article, the policy of APSARA Authority is to reuse the ancient hydraulic system (see Figure 6.1). Following this instruction, the Key Water Structure of Water System in 12th century in laterite and sand stone (see Figure 6.4 and 6.5) has been replaced by new Watergates nearby call Ta Som Water Gates, it's a little bit downstream of ancient water structure (we preserve it as heritage and evidence of historical) and 49 kilometers of canals and dikes to be restored to assure the connection of four rivers – Rolous, Siem Reap, Pourk and Stung Preah Srok and also the connection to Barays and moats of the whole system. This rehabilitation can be assuring again the flow of 110 billion litters.

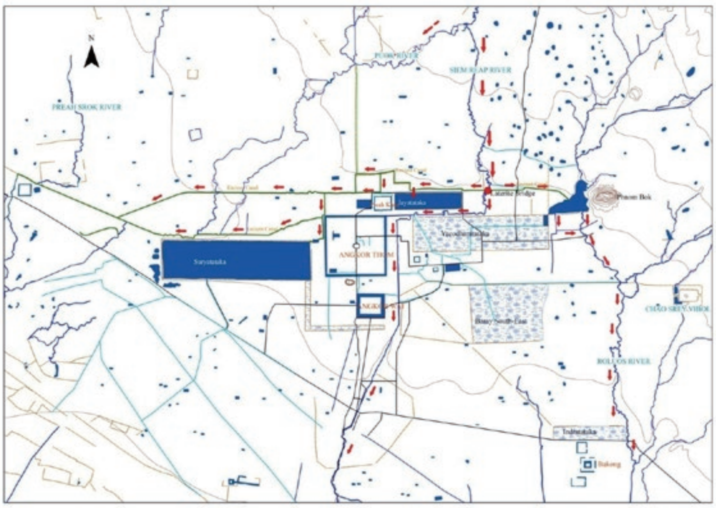

Figure 6.1: Angkor Hydraulic network with flow directions

It needs to go back to history by looking at the record of Angkor city in ancient times, and how they can face this challenge with their complex hydraulic system. After our research, no inscription in Khmer Empire territory mentioned about the flood or the drought in the Angkor region. Otherwise, the Khmer people should have a memory of the disaster and transfer that information to the next generation or use as a legend. If those problems never happened in the past, it means that the water management system in ancient times was the best system to optimize water resources. Because of the ancient system was not functioning for a long time, that's why in 2004 it has drought- the Angkor Wat moats and Srah Srang dry up, and then had floods in 2009, 2010, and 2011.

Figure 6.2: Flood control at East Angkor Wat moat in 2009 (1)

Figure 6.3: Flood control at East Angkor Wat moat in 2009 (2)

Figure 6.4: Key water structure of the hydraulic system in the 12th century at Ta Som – in the river bed

Figure 6.5: Key water structure of hydraulic system in the 12th century at Ta Som

7.The New Technology with the Millennium Angkor Hydraulic System

To understand the intricacies of the Angkor hydraulic complex today and the continuity with the sophisticated and impressive hydraulic system built during the great Angkorian period (from the 9th to 13th centuries), and manage as demonstrated above article, our PAAGERA teams (Projet d'Amélioration de l'Assainissement et de la Gestion des Eaux dans la Région d'Angkor), since 2012 is trying to introduce the new technology step by step in our daily management such as data collection system on rainfall, water level and other parameters to allow the managers for quick intervention in term of disaster management.

The PAAGERA project is a cooperation project between APSARA National Authority and

French agencies like SIAVB (Syndicat Inter-communal de la Vallée de la Bièvre), SIAAP (Syndicat Interdépartemental pour l'Assainissement de l'Agglomération Parisienne) and AAA (Association des Amis d'Angkor) in which it has a contract with water specialist firm in Paris, Hydratec of group SETEC. The result of the feasibility study has confirmed the efficiency of the discovery and rehabilitation of the Angkor Hydraulic system for the Angkor region by the APSARA National Authority and agreed on the APSARA's vision to continue to rehabilitate of remains Angkor water structures.

Based on experiences of SIAVB, the team wishes to set up an automatic system of real-time decision in place by introducing High Technology in daily management, it means the water gates will be operated by motors in synchronization with data collection in real-time from the different sites in Angkor region. Since the beginning of the project (cooperation started in 2012 then signed official MoU in 2014), meteorological stations and water levels stations were installed in the watersheds of Siem Reap, Pouk, and Rolous to collect and set databases and provide detailed information for future Decision Support System (DSS) for Angkor Park region.

The new phase of the project started in 2022 called SDGERA project (Système d'aide à la Décision pour la Gestion des Eaux de la Région d'Angkor), its MoU was signed during ICC-Angkor meeting in December 2022. The objective is to have real-time access to the hydro-meteorological and hydraulic system state during a flood event. Rainfall and water level data that are transmitted to the APSARA remote center should be received at a higher frequency rate, also the position of the gate opening should be known at all times. The gates are to be motorized in priority in order to develop an efficient real-time control system against floods.

The project teams try to simplify and put all information into to schematic of the computation system to do the calculation and simulation of the reality into the core system (see Figure 7.1).

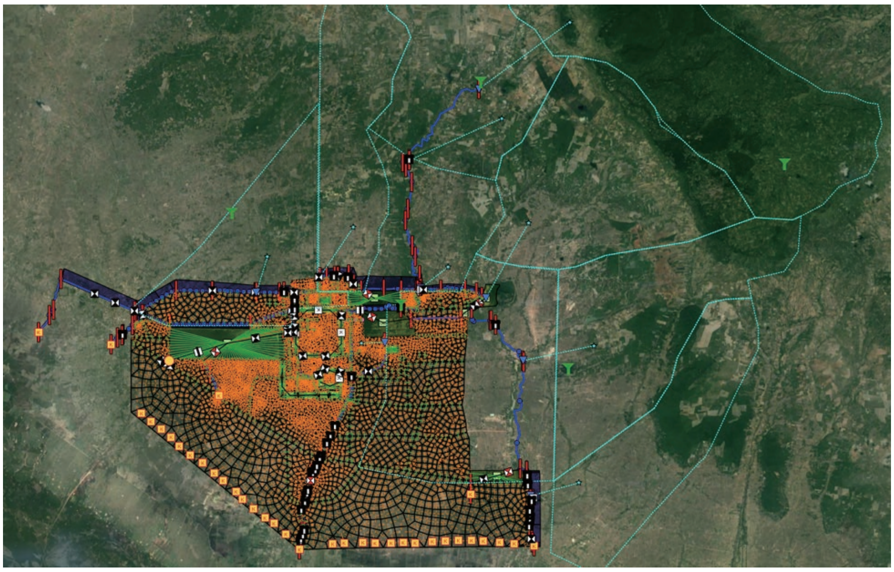

Figure 7.1: General layout of Hydraulic Model of Angkor region

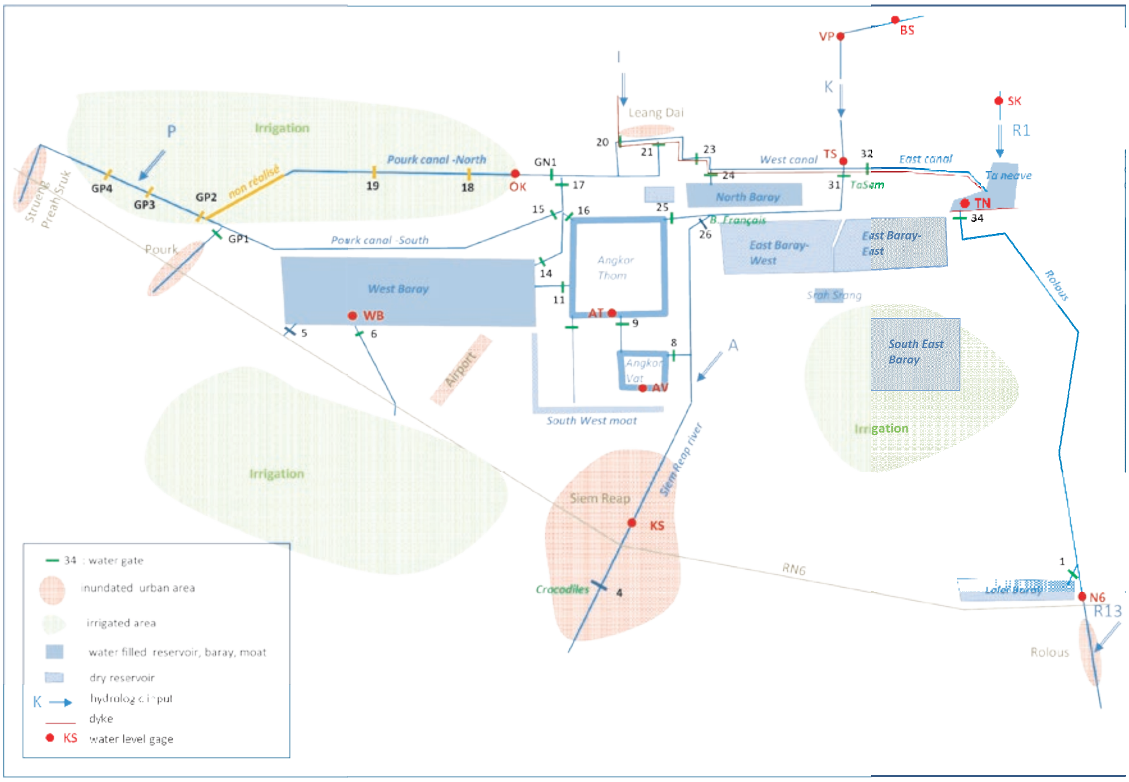

Figure 7.2: Schematic of Angkor Hydraulic network in region

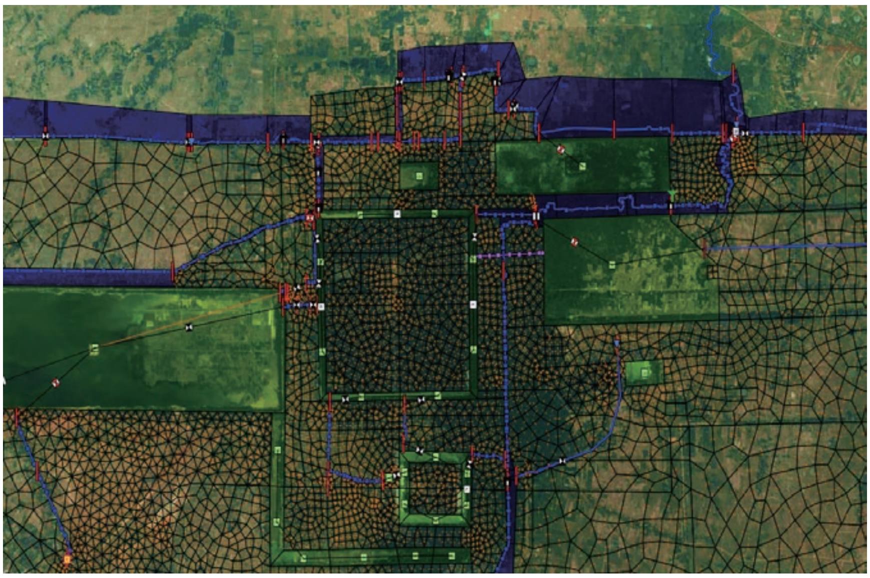
Figure 7.3: Structure of the hydraulic model in the Angkor Park

The purpose is to develop gradually an optimized system that would help APSARA National Authority operators in choosing the "best" strategy to manage the gates at regular time intervals during a flood event and optimization of water resources management as Khmer ancestors: "Nondrop of water can't pass the Angkor region without use". This is a long-term objective that shall be gradually approached along with the accumulated return of experience.

This approach towards optimized control will be based upon (see Figure 7.2 and Figure 7.3):

· Hydrologic and hydraulic modeling with hot starts to yield short-term evolution of the hydraulic system,

· Optimization software components to calculate the best strategy, given the current state of the system (from real-time data) and prevision data from the hydraulic model

8. Conclusion

The evidence and result of the rehabilitation of the ancient hydraulic system proved the capacity and efficiency of the system for sustainable use of natural resources and prevention of natural catastrophes. We are insured that in the era of Angkor prosperity, this imperial capital had efficient hydraulic engineering, coherent and systematic. The glory of Angkor is inscribed on the memory of water.

The most important task that we have is to rehabilitate urgently all Angkor Hydraulic structures in the region that are more critical than stone temples. Even if they collapse, the temples can always be restored, but the Angkor hydraulic structures are in soil, if they are destroyed it will be forever. It's why we recommend rehabilitating the East Baray, Lolei Baray, and South-East Baray. If we achieve the rehabilitation of ancient reservoirs like Barays, moats, ponds, and canals, it will be again the Glory of Khmer Culture (the Angkor hydraulic system is the footing print of Angkor city), its history, cultural landscape, economy (can be used as water supply sources tor villagers around and future development of Siem Reap city), climate change, disaster management likes flood (can avoid the flood in the temples, village and Siem Reap city) and drought (collect the water during the rainy season to prevent the lack of water in dry season), Stability of temples (storage in these reservoirs are driving the recharge into underground water to assure the stability of temples).

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Reflecting on the 22 years that have elapsed since the First International Symposium on the Hydraulic City, (2000)

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Let me first express my sincere thanks and greetings to Professor Ishizawa for his invitation to participate in this symposium. Unfortunately, my new responsibilities as head of the EFEO Center in Chiang Mai, starting November 1, come at a time when this city is hosting one of the largest archaeological congresses in the Asia-Pacific, the Indo-Pacific Prehistory Association (IPPA) Congress (which was also held in 2014 in Siemreap). On this occasion, the EFEO centre is hosting several major scientific meetings, and all of this constitutes a busy context that really does not allow me to be with you today, and I am very sorry about that. I am all the more sorry because I know how much attention and kindness Professor Ishizawa has always shown to me and to the French School for Asian Studies, the EFEO. As a reminder, I would like to mention, for example, the memory of the first EFEO-Sophia University scientific meeting that we organized together in 1994 in the Grand Hotel in Siemreap, which was still dark and deserted, long before it was restored as the luxury hotel that we know today.

Since I cannot be with you, it is a modest consolation for me to send you this message that Professor Ishizawa has invited me to propose to you today, in the form of a reflective note on the symposium on the question of the hydraulic city, which was already organized here in Tokyo at dawn of the new millennium, more than 20 years ago. My thanks also go to Professor Yoshiharu Tsuboi for agreeing to read this unpretentious note today, as well as for the rich exchanges we had almost 30 years ago during our respective stays in Cambodia and Japan, which I still remember vividly, especially in culinary terms.

Such a return to the past is of course not neutral, since it invites us to put into perspective two decades of works, and even to draw up a balance sheet of these actions, going through the satisfaction of the work accomplished and the identification of the progress made, the observation of certain missed opportunities, or sometimes errors of interpretation, pitfalls that are today regrettable but necessary as they are an integral part of research and of the constitution of our knowledge. Apart from the nostalgia naturally inherent in the 20 years gone past, we must unfortunately also mention the passing of several of our late colleagues who contributed to the advancement of our knowledge of Angkor. I would like to mention the constructive and determined dynamism of Nabuo Endo, Hisao Harahi's pioneering works on monumental chronologies and wooden structures, Jacques Dumarçay's benevolent guidance and sharing of experience, the stimulating exchanges with Pascal Royère, whose last complex work site involved restoring the Western Mebon, and the friendly jousting with Professor Claude Jacques, who was always willing to advance our knowledge of Angkor history. Finally, it is difficult not to mention the communicative energy of Vann Molyvann and the clear-sighted listening of Deputy Prime Minister Sok An, and their essential role in promoting international research on Angkorian urbanism and hydraulics.

This sad reminder of our departed colleagues and friends also invites us to place this 20-year period on a quasi-generational scale in the context of Khmer studies, and Angkorian hydraulic studies more specifically: almost 90 years since Georges Trouvé's observations and the pioneering trials of the Service Hydraulique de l'Indochine at the Western Baray, 80 years since Victor Goloubew's first article on 'Urban and agricultural hydraulics at the time of the Angkor kings', More than 50 years since BPG's series of articles that led to the one on 'La cité hydraulique angkorienne' and, as a counterpoint, to a debate of interpretations, people or ideological schools that I described here 20 years ago as a 'dialogue of the deaf'.

It would be peremptory to affirm that this dialogue of the deaf still persists today, after more than 20 years, even if several indications may suggest it is still partially the case, and I would rather like to return modestly to two particular points linked to the symposium which took place here in 2000 on this - now famous - theme of the Hydraulic City.

1. Angkorian Hydraulics: false dogma or real theory?

The first point invites us to question this 'notoriety'. At least to note a contrasting, even paradoxical, situation between the general theme of Angkorian hydraulics and the theorisation proposed by BPG in the 1970s. The general theme of hydraulics had benefited from real dissemination, well beyond the academic sphere, and this happened well before BPG's work. This diffusion was favoured by the obvious monumentality - not to say the misleading gigantism - of the Angkorian hydraulic works (barays, moats, bridges, roads, etc.) and, from the 1950s onwards, by the rise of hydraulic and agricultural issues in the world in general and in Cambodia in particular, in regards with the development policy of the newly independent country. In this context, BPG's rare contributions before 1970 appear very general and generally rather anecdotal when they leave the academic field, especially as they seem to be in phase with the concerns of the time[1]. This is also the case for his 1967 article entitled "Angkorian civilisation and the mastery of water", a short contribution published in Khmer in the widely circulated Sihanoukist daily "Neak Cheat Niyum" (The Nationalist). Let us recall that BPG was then in charge of the Conservation of Angkor on behalf of the Cambodian government, and the political dimension of his article is unmistakable when we read in it that "the Angkorian Empire perished by the very fact of its own genius" and that he concludes as follows: "If the wisdom of the nation and its leader can also avoid the pitfalls of passions, then without doubt the Khmer country can once

1 For example a paragraph in Groslier 1956, or a few pages in Groslier 1958. Similar statements can be found earlier, for example in Briggs 1951.

again become that immense opulent rice fields around the great lotus temples in full bloom".

It is therefore only half surprising that some authors, taking up the criticisms of Groslier's theory by using amalgams and anachronisms, have sought, including in the last 20 years, to suggest a link, or even a causality, between Groslier's writings and the excesses that followed, notably the murderous hydraulic works undertaken by the Khmer Rouge regime[2].

Paradoxically, it was precisely when this period of turmoil had already begun that BPG set out the formula of the Hydraulic City and developed its concept in two articles, the 1974 paper "Agriculture et religion dans l'Empire angkorien," in *Études rurales* and the 1979 paper published in the *BEFEO*, "La cité hydraulique angkorienne: Exploitation ou surxploitation du sol". For the sake of accuracy, the second one was probably written very shortly after the first one - which explains their complementary approaches - since it was circulated as early as 1975, as indicated by Claude Jacques[3], who contests various chronological points in an article published a year before *La cité hydraulique*.

To come back to the point I am interested in today, it should be noted that these two academic articles, written in French, were published relatively late, and in French scientific journals of limited circulation. Often cited by opponents of the hydraulic theory, one can nevertheless wonder about the extent of their real diffusion. I have often doubted whether they have really been read by some of those who was debating about them. This was particularly apparent to me at the 2000 symposium in Tokyo. And it was after this symposium that I decided to translate Groslier's 1979 text into English. In parallel, a Khmer translation was fortunately published in Phnom Penh in 2003 by Nouth Narang[4]. The English version was finally published in the journal *Aséanie* in 2007[5], thanks to the tireless and diligent efforts of Terry Lustig, a hydraulic engineer and collaborator of the Greater Angkor Project, who, like me, thought it would be useful to present this text in detail, considering that "one should not then dismiss [the *cité hydraulique*] solely as a product of a colonial vision or a simple application of theories of Wittfogel, thereby 'throwing out the baby with the bath water'".

Allow me to quote from the presentation of this English translation, which summarises the motives of this undertaking as opposed to a slavish and blind rehabilitation: ". why revisit [the *cité hydraulique*] when recent research at Angkor has rendered a number of its facts and figures null and void—and so certain of its conclusions? […] While several authors quite evidently have sufficient command of French for citing and commenting on the original, translating this quite dense and complex article from scratch has confirmed to us that a good number of references to, and critiques and judgements of the ideas contained in La cité hydraulique are based on a comprehension, if not biased, at least partial. We will pass over the quite strong positions taken by

2 Following Stott 1992, see for instance Locard 2008, Locard 2011, Locard 2015. On the exaggeration of these interpretations, see notably Sher 2003.

3 Jacques 1978.

4 Groslier 2003.

5 Lustig & Pottier 2007: 133-140.

people who have never attempted to read the original article. What is of greater concern is that, too often, some of Groslier's writings have been presented in a simplistic and misleading context, such as the outlandish idea of the development of a vast network of irrigated rice fields producing two to three crops a year, or the one of an occupation density approaching two million inhabitants at Angkor. Let us hope that this translation will enable some of the English readership to move beyond these stereotypes, if only to become better informed of the principles on which Groslier bases himself, and above of all the numerous caveats and warnings which he puts forward throughout his work. […] Nevertheless, we are not naively hoping that this translation will simply correct the stereotypes towards which, after all, given its challenging title and some of its "shock" phraseology, the original text contributed. Nor are we expecting that it will close the debate that it started. Rather, scholars will need to continue the study of the Angkorian society, and acquire much more knowledge in order to propose a significantly new interpretative model".

With 20 years' hindsight, I don't know if the English version has been read that much, and of course there are still caricatures or exaggerations of BPG's theory, encouraged in particular by increasingly varied contributions, but whose nature is diversifying to the point where they are more media productions than academic works. But the need to continue to acquire new knowledge seems to me to have been more productive and brings me to the second point I wish to address here.

2. A research rooted in the field

One of the most striking points since the Tokyo symposium on the hydraulic city was held in 2000 seems to me, with hindsight, to correspond to the extent and scope of the new knowledge acquired in the field, and in particular that obtained through scientific investigations which I was calling for at the time. I wish I could say that this was a direct consequence of the conference, but I fear that this is not really the case, and field investigations have since been carried out by a number of different actors, few of whom had actually participated in the Tokyo discussions. But it doesn't matter, and in that sense the symposium was very much in line with the research that was aimed at gradually and increasingly taking into account the environment of the temples, the Angkorian territory and its evolution over time. This phenomenon related to taking into account the scale of the site and the complexity of its composing elements that are representative of its heritage, and we can hope that this knowledge will contribute to their harmonious contemporary management, dealing concomitantly with conservation and development.

In my modest contribution in 2000, I wanted to emphasise some of the characteristics of the debate that had developed since the publication of BPG. The contestation of his theory was occasionally based on biased 'productivity' tests which, in my opinion, were - and still are in part - premature in the absence of sufficient detailed data. But the most common challenge at the time was to assert the absence of any physical remains of hydraulic structures - execept the barays. This claim was often supported by ignorance of field data, possibly coupled with a certain scientific "a priorism". I then mentioned a few cases to attest to the very real existence of hydraulic structures (Beng Mealea, Angkor Thom, eastern baray, etc.) previously reported in archaeological surveys, and even the empirical example of Georges Trouvé's work to empty the western baray in 1934. In this respect, the two decades have since led to the discovery and excavation of many other hydraulic structures, some of which are of considerable and unsuspected scale (Bam Penh Reach, Krol Romeas, western baray, Jayatataka and Indratataka, etc.). When they have been excavated, they have also revealed a clear technical diversity, sometimes quite elaborate, and a complex history that shows variable uses over time. His Exec. Dr Hang Peou and my colleague Prof. Roland Fletcher have probably already demonstrated this brilliantly, so I won't go back over it again, except to emphasize that the Khmers did indeed used complex hydraulic structures and that they did not hesitate to modify and adapt them to changing needs or conditions. This invites us not to consider a monolithic hydraulic theory unchanging over time, but to consider an evolution over the centuries, which Jacques Dumarçay, for example, defended by proposing an interpretation of bridges that he considered to be a late invention.

Variability is another element that has appeared over the last 20 years. Let us recall that, overall, BPG felt that environmental conditions in the Angkorian period should not have differed greatly from our present conditions: [The 'hydraulic city hypothesis'] 'rests on the assumption that the climate of Siemreap between the ninth and twelfth centuries was much the same as it is today'. Paleo-environmental research undertaken since 2000 at Angkor, notably that of Dan Penny[6] (USYD), and more broadly in the region - notably the work of Brendan Buckley[7] (Colombia) - now makes it possible to identify important developments that bear witness to changes in hydraulic regimes and significant variability in climatic conditions, notably monsoonal regimes. This put diachrony back at the heart of any understanding of Angkor and its development.

In my 2000 contribution, I therefore also stressed the importance of going back to the realities of the field and taking into account the field data, whether empirical experiments from the 1930s or new data, in order to question hypotheses or at least move forward, even if it means contradicting and abandoning some of hypotheses along the way. *Prima caritas incipit a se ipso* or "Charity begins at home", I will therefore give here an illustration, at my own expense, of advances that led me to contradict one part of my 2000 paper! Building on the momentum of my doctoral thesis, in which I presented a new detailed archaeological map including the discovery of "fossilized" rice fields parcelling, I proposed in 2000 a reappraisal of the area south of the southwestern corner of the western baray, (of the dating of certain elements and of its morphological genesis). The concomitant discovery of a regular succession of earth mounds to the south bank of the baray dike and a grid of canals (previously unknown and not mentioned by BPG, who had only noted the outer moat and ditches to refer to a pre-Angkorian city that he had

6 Penny, Pottier, Fletcher et al. 2006. Penny & Pottier 2005: 497-521.

7 *www.pnas.org/cgi/doi/10.1073/pnas.0910827107 PNAS*

improperly named Banteay Chhoeu) led me to formulate the hypothesis that these mounds and canal grid were linked. Furthermore, the identification of ancient rice fields patterns opened the way to a morpho-chronological analysis that associated them with the canals and causeways to the south of the grid, thus establishing a morphological relationship between the baray and the rice-fields downstream.

Ten years after the formulation of this paragraph of my thesis, which aimed to resolutely challenge the existing vision of an Angkor urbanism restricted to enclosing walls, like the example of Angkor Thom, several elements have come to cast doubt on the contemporaneity of this canal grid with the western baray: our 2000 and 2001 excavations in the area, and in particular at Kok Phnoeu, did not provide the conclusive elements we had hoped for; in 2009 the association of the earthworks and the canal grid was called into question (in a footnote by Bourdonneau 2009); then the 2012 Lidar archaeological mapping of the Kulen (KALC)[8] confirmed the dissociation between urban grid and enclosure city moat, a dissociation further paradoxically reinforced with the discovery of a grid at Sambor Prei Kuk revealed by Lidar (CALI Evans 2015); finally, our excavations at AKY and at other sites in the region between 2012 and 2016 (Poy Ta Chap and Pr. Trapeang Sen), then the mapping survey carried out in the baray bottom during an exceptionally dry period in 2016, have finally laid to rest our 25 years old hypothesis, and dissociate the genesis of the agrarian parcelling of this area and the creation of the western baray, both from a chronological and functional point of view.

But if research sometimes leads to contradiction, it also excels in producing new discoveries. This was the case for this region since, in addition to the pre-Angkorian antiquity of the canal grid, the vision of this first city in Angkor - which I have since proposed to identify[9] with the Bhavapura founded by Bhavavarman I - was enhanced by the presence of a proto-baray to the north, partially concealed under (and levelled by) the western baray, and of the same size as the Indratataka. For the sake of accuracy and precaution, so as not to have to come back in 20 years' time to contradict myself again, I would like to point out that our excavations have not, for the moment, been able to date its construction prior the 9th century, even though it seems likely to me that this structure is older.

In conclusion for this too long "little note", I insist again on the importance to favour research and inherent debates for the advancement of our knowledge, including on other components than hydraulics, notably on agriculture and culture. And I still stress, even after 22 years, the need to maintain and develop field investigations, which are the only way to provide us with the elements that will constructively feed our reflections and confront our interpretations. I would like to conclude by saying that 22 years have gone by so quickly, which is probably even faster when you have the privilege of working on a site as exciting as Angkor, where you sometimes lose track of time.

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8 Chevance 2014 : 279-330. Chevance, Evans, et al. 2018: 1303-1321 (issue 2019). DOI: https://doi.org/10.15184/aqy.2019.133

9 Pottier 2017: 43-79.

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Closing Remarks

H. E. Tuy Ry
Ambassador of the Kingdom of Cambodia to Japan

Today, I wish to congratulate all those who were involved inthe Sophia Symposium, which was held to commemorate the 25th anniversary of the foundation of the Sophia Asia Center for Research and Human Development. The historical, social, and economic foundations of Angkor, a civilization that has achieved great prosperity, has been actively explored by five experts, from Cambodia, Australia, France, and Japan. These are scholars at the very forefront of their research, and they have conducted their study in a truly creditable manner. It is indeed an honor for the Kingdom of Cambodia to report, discuss, and convey from Japan the great prosperity of Angkor Empire, to rest of the world.

Based on the results carried out since 2004 by APSARA National Authority on research and rehabilition of the ancient water management system which is forgotten, how it works, more than five hundred years. The rehabilitation of Angkor Hydraulic System contributes significantly not only to the preservation of the monuments and the development of Siem Reap city, but also to the Outstanding Universal Value (OUV) of Angkor World Heritage Site. I would therefore like to congratulate their archievements.

As you all aware, the restoration project of the Angkor Wat Western Causeway is now in progress, thanks tothe joint efforts carried out between the APSARA National Authority and Sophia University. At the restoration site of Angkor Wat, which happens to be a temple revered by all Cambodians, the training of Cambodian conservators and stonemasons is also being achieved. The first phase of the restoration project was executed during the years 1996 to 2007.The second phase is currently underway, and it was scheduled to be conducted from 2016 to 2024. The retaining wall of the causeway is now being preserved, and the central terrace is being restored. We are also preparing to welcome visitors to Angkor.

I would like to express my sincere gratitude to the organizers of today's international symposium,and I would also like to inform you all that Professor Yoshiaki Ishizawa has been awarded an honorary doctoral degree in history and humanities, from the Royal University of Phnom Penh. The ceremony was held on November 1st, 2022. Professor Ishizawa's academic contribution to Angkor over 50 years, his voluntary activites for the training of Cambodian conservation officers, and other similar attainments, were all highly evaluated by the Southeast Asian nations, as a result of which he received the Ramon Magsaysay Award. This was also a reason for having awarded him the honorary doctorate. Professor Ishizawa, Congratulations!

In conclusion, I wish to close my brief remarks by expressing the hope that the restoration of the Angkor Wat Western Causeway, will further promote friendly relations between Cambodia and Japan.

Thank you very much for your kind attention!

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