2018-2019

ADAPTATIVE LOWLAND RICE CULTIVATION IN THAILAND AND CAMBODIA

A COMPARATIVE STUDY OF HOW TWO LOWLAND AREAS DEVELOPED THROUGH ADAPTIVE RICE CULTIVATION

HESTER DIJKSTRA
S1470434
Leiden University, MSA PSE THESIS

Contents

1. Preface

> *"Little wonder that the greatest horticulturalists have come from the Orient, where nature is not considered passive "*[1]

1.1 Introduction

Modern-day strategy and practice regarding agriculture in flood prone low-lying lands is to build dams, block rivers and create large irrigation systems. Examples are; the Three Gorges Dam in China and the many (planned) dams in the Mekong river.[2] Such projects have altered the environment, altered the flow of the river, the land and ultimately the life around it. Since colonial times the primary response to flooding has been to prevent it. By building structures that could alter the flow of water, sustain or retain it. There are scholars who believe that agriculture has been able to thrive in the lowlands by preventing floods.[3] Especially for lowland areas it appears that growth in agricultural production is linked to colonialism and the transfer of knowledge. Growth in production was, allegedly, initiated during the colonial times.

Following this colonial discourse produced by scholars such as Ravesteijn, it appears as if the Southeast Asian lowlands were uninhabited and only cultivated as a result of colonial initiatives. Ravesteijn, for example, describes the colonial bureaucracy and engineering of the Dutch in Java as a positive presence regarding water management. In his view, agricultural productivity rose as a result of the measures taken by the colonizers to curb the flow of rivers. This, however, is not the full story. The dams, irrigation systems and other means of invasive water management, regardless of colonial influence or indigenous skill, are not the only means through which lowlands in Southeast Asia have been able to flourish. Societies in the past have been successful of establishing cities, large-scale agriculture and see a high population density in lowland areas with little to none invasive water management measures. Their relative successfulness in flood management and agriculture was owed to adapting to their low-level environment; to the seasonal occurring floods.

Some of the lowland areas in Southeast Asia that have been already inhabited before colonialism are for example the Irrawaddy river delta located in Burma, the Red River Delta in Vietnam, the Chao Praya basin in Thailand and the Mekong river basin in Cambodia.[4] These areas were used for their agricultural potential. The varied climate fostered specific groups who specialized in the exploitation

---

[1] Hanks, p 23.
[2] Mekong Mainstream Dams at International Rivers, https://www.internationalrivers.org/campaigns/mekong-mainstream-dams (accessed 14-10-2018).
[3] For example; Ravesteijn.
[4] Hanks, p 4 (map 1).

of certain resources within their environments.[5] From a cultural perspective, these Southeast Asian societies were successful in adapting to their highly varied climate.

The phenomenon, through which these societies were able to live in the lowlands and floodplains of the rivers, was flood retreat agriculture. This included the use of floating rice varieties. The method of flood retreat agriculture required relatively low levels of technology, low levels of input and were simple to put in operation. Because of these adaptations, people were able to sustain themselves which resulted in a growing population. Some of these areas were even able to grow into large hubs for the inter-regional trade. To illustrate; the Ayutthaya kingdom flourished through trade. Just as the area around Tonle Sap, though trade here focused along the Mekong river.

How the lowland regions around the Thai city of Ayutthaya and the Cambodian lake of Tonle Sap developed their sophisticated agriculture by adapting to their flood prone environment is the central subject of this thesis. The adaptation rather than altering the lowland environment is considered as a sustainable and successful means of development in the history of these areas. The goal of this thesis is to provide a side-by-side analysis of the adaptation in agriculture and the subsequent development in the Chao Praya basin in Thailand and the Tonle Sap lake in Cambodia. Both these areas have had large scale agricultural production in ancient times. These areas are still characterized as (one of) the centre of agricultural production in their country. They also have been the stage for ancient societies and their ability to sustain the agriculture through flood adaptation.

1.2 Methodology and research question

This thesis will contain a comparative analysis into the floodplains of the Chao Praya basin around Ayutthaya in Thailand and the Tonle Sap lake which is in the lower Mekong river basin in Cambodia. These regions see rather large differences between seasons with periods of drought and rainfall. They, currently, are characterized as well by the many smallholder farmers and the specialization in rice cultivation. The research will focus on the development of these societies in the lowlands and how they were able to sustain themselves in terms of rice cultivation through flood retreat strategies. The development of rice cultivation is argued to take place independent of colonialism and that colonialism did not play a determining role in the growth and success of the areas. Summarizing, the main research question is: *How did the adaptive style of rice cultivation affect the rise and development of lowland regions in Southeast Asia?*

In order to answer this question a comprehensive research is applied, encompassing an analysis over a long period of time. The adaptive non-invasive means of rice cultivation will be analysed; the means of production, the varieties and the role in the successful development of the low land regions.

[5] Miksic, p 11.

The areas of research two are lowlands areas in Southeast Asia. The two regions specifically chosen for the analysis are the Chao Praya basin in Thailand and the Great Lake, Tonle Sap, in Cambodia. Both lowland regions have seen population growth, are the sites of large archaeological discoveries, are in the tropical savanna climate and are the ‘rice bowls ‘of their country. As opposed to the Irrawaddy delta in Burma and the Red River basin in Vietnam, the Chao Praya and Tonle Sap are less researched and fewer sources are available.

The adaptative and non-invasive means of agriculture refer which is practiced without considerable changes being made to the environment. Rice cultivation is the main point of focus for it is a staple in the Southeast Asian diet. The use of rice as a crop to sustain the societies and more importantly to ‘adapt’ rather than ‘change’ as belief opposed of the colonial discourse. The cultivation of floating rice, deep-water rice and other rice varieties that can sustain themselves under many conditions. Development in this thesis will refer to the relative productivity in the region, accompanied by growth in population, infrastructure and more. Development is expected to correlate with the ability to adapt to flood regimes in the environment, risk reduction and water management. This is measured through available sources that contain information on among other population density, land use and other relevant economic, agricultural and ecological characteristics.

1.3 Structure

This thesis is structured in five chapters. The second chapter of this thesis will focus on the theory behind agroecology, agricultural adaptation and research into development over time. Then the focus will shift to researching the multi-dimensional nature of agriculture, ecology and adaptation in the Chao Praya basin in Thailand and the Tonle Sap lake in Cambodia in Chapter 3. Chapter 4 will provide a developmental timeline of the two regions from the first civilizations until today. The most important events will be highlighted as well as the challenges the regions have faced. The final chapter will summarize and answer the main question.

2. Theoretical framework

"Contrary to the popular belief that nature always remains the same –....– nature changes profoundly whenever man, in response to simple or complex historical causes, profoundly changes his technical equipment, his social organization, and his world outlook"[6]

2.1 Developmental studies

In modern developmental studies the subjects of interest are resources, resource management, agriculture, trade and population. In addition, current studies on development focus largely on recent development. Recent, referring to the post-colonial period, approximately from the 1940's to modern days. [7] The subjects of development for the sake of this thesis, encompass the agricultural development and population growth from ancient times to nowadays. This thesis, as opposed to other studies, is not limited to a recent timeframe. Rather, it aims to compare the historical rise of the region and countries in their indigenous forms. The line of arguing is that indigenous style of adapting to the environment is preferred over transforming the environment in the colonial discourse.

One of the main theoretical beliefs of the developmental scholars is that human development depends on the physical resources available.[8] Scholars have researched Southeast Asia from a perspective that puts the colonial activities central, significant and essential for kickstarting the development in Southeast Asia. In that view, it was the colonial powers that were able to exploit the resources to their full potential.[9] The narrative must be nuanced and more directed at the developments that took place before and independent of colonialism, chiefly developments in agriculture and the cultivation of rice in Southeast Asia.

The belief that human kind is a part of nature and that nature has a value to society which must be respected. The ability of people to adapt to nature and their environment ultimately influences success.[10] A factor influencing adaptability, as mentioned above, is the management of resources. In that line of thinking, Potter et al. describe water resource management as fundamental to human existence and economic development.[11] They also state that the agricultural production is of major importance to developing countries, but they particularly refer to water withdrawals. With their assumption of Potter et al find that for modern day development water is essential, as well as

[6] K. Wittfogel, p 11.
[7] R. Potter et al, p 5.
[8] R. Potter et al, p 227.
[9] J. Kop & Ravesteijn, p 17.
[10] R. Potter et al, p 228.
[11] R. Potter et al, p 232.

fundamental. They however not fully embrace the school of thought of people adapting to seasonal influxes and the value of natural processes.

The availability of water has shaped the developmental process from ancient times. For the process of rice cultivation water was important; rice thrives in water.[12] An example from ancient India is that people build cities in the lowlands, near relatively stable rivers on safe sites, rather than choosing sites near fast-flowing flashy river.[13] The availability of water and the interaction with the environment allowed for people to sustain themselves in the flood prone lowlands.

The influence of outside forces, also, cannot be underestimated. The colonial powers had a profound influence in which the environment in Southeast Asia was changed and, more importantly, sought to be exploited. Anthony Reid in his essay 'Inside out' refers to the case of not only displacement of the population due to colonization but also the introduction of new crops, new diseases and the growing influence of market demand.[14] The outside influences have been in the shape of colonial powers; the French in Cambodia or the presence of Westerners in the ruling elite of Thailand.[15] The change of perspective these outside forces brought, was a technocratic viewpoint from which exploitation of rice cultivation was a goal.

The western scientific perspective is shortly summarized in four points. Firstly, that Asiatic states always depended on rice. Secondly that in order to cultivate rice water is a necessity. Thirdly, because water was scarce or unpredictable in the least in Asia, water had to be brought in through irrigation structures or otherwise man-controlled forms. And fourth, in order to exploit the system to its maximum the man-made structures had to be governed by a strong elite or state.[16]

This perspective is incomplete. The Asian population, as mentioned before, used rice in the early days for sustenance and the surplus was taxed. In the wet rice cultivation system, of for example Thailand when it was still referred to as Siam, this meant no irrigation works were necessary to get increased revenue.[17] Another factor is that in the social system in Siam, irrigation simply did not pay off, for wet rice required minimal external input to create a substantial output.[18] Even when the Asian states became dependent on rice cultivation for market purposes there was a division between the colonial market aimed cultivation and exploitation and the original population producing for their own consumption.[19]Western colonizers also had separate priorities; overtaking cultivation, the creation of infrastructure, maintaining influence and raising funds. When irrigation, for example, 'failed' in Siam

[12] I. Norlund, p 15.
[13] A. Agarwal, p 146.
[14] A. Reid, p 3 and p 15-16.
[15] J. M. Pluvier, map 44 and the H. ten Brummelhuis described history of Homan van de Heide in Siam.
[16] H. ten Brummelhuis, p 13.
[17] Ibid, p 14.
[18] H.J. Nesbitt, p 69 and H. Ten Brummelhuis, p 21.
[19] K. Helmers, p 2 -3.

due to the priority towards railway building, the lack of advantage to irrigation for the elite, insufficient government funds and the prioritizing in the commodification of rice. [20] On a more personal level, the efforts of Homan van der Heide, though later applauded, failed not only due to the above reasons but also due to the lack of eye for the native means of cultivation from his personal understanding.[21]

In conclusion, a western viewpoint of commodification of rice for the world market through technology and bureaucracy in the colonial was unsatisfactory. Rather, it made the countries depended on the crop for international trade to the west. It attempted to alter the means of production in favour of increasing revenue by changing the social system, the means of production, the type of crop and the availability of water. The cases of Thailand's Chao Praya basin and Cambodia's Tonle Sap are much more nuanced than the colonial changes to the water management and crop cultivation. While the colonial commodification has had a substantial role in changing the outcome it was not nearly as successful as usually portrayed.

2.2 Adaptation and change to the environment

The interplay between landscape and people has shaped history. Hunter-gatherers became farmers and settled. In arid and humid corners of the world, man adapted. If there was water, man would curb the water and learn how to use it.[22] In terms of adaptation, a case may be made for the adaptation being achieved through changes in technology. According to Ravesteijn it was not adaptation but technology that fuelled the success of large-scale agriculture. His quotation of Hollick on the realization that technology is a controllable force for human betterment, underscore his beliefs.[23] His research projects are concentrated to Indonesia, or Dutch East-Indies at the time and focuses on the improvement of irrigation systems. He found that the irrigation systems in place at the start of colonialism were incapable retaining enough water, maintenance was bad and the social/political infrastructure inadequate.[24] Significant is the statement of Ravesteijn & Kop: "*The Dutch engineers cannot be accused of lacking courage: they came, they saw and conquered tropical nature."*[25] The colonial engineers altered the environment drastically and in turn have been credited by Ravesteijn and other scholars as essential to the agricultural development of Indonesia. Their creation of sophisticated bureaucratic hydraulic societies is seen as a positive aspect to colonialism.

Alternative to Ravensteijn, scholars such as Wittfogel have argued in the favour of 'hydraulic societies'. Societies which by means of irrigation systems were able to increase productivity

[20] H. Ten Brummelhuis, p 346.
[21] Ibid.
[22] K. Wittfogel, p 12.
[23] W. Ravesteijn, p29 from Hollick (1982), p 226
[24] W. Ravesteijn p 14.
[25] J. Kop & Ravesteijn, p 410.

independent from colonialism. In the view of Wittfogel the hydraulic societies were able to adapt, not only, through technological change, but by changing the social organization and world view.[26] The possibility to cultivate potentially fertile lands required useful plants, an arable soil, sufficient humidity, suitable temperatures and an appropriate lay of the land.[27] Finding the proper soil and plants were relatively easy manipulated for a farmer, water a challenge and temperature and relief unchangeable.[28]

Angkor in Cambodia, notably, in this sense is not considered a 'hydraulic state' for its agricultural surplus and sustainability was based on a local-level adaptation to the environment.[29] However, fully fledged hydraulic societies such as in Northern Vietnam and Southern China. These regions saw sophisticated hydraulic engineering feats in the form of irrigation systems.[30] Irrigation, dams and other means of altering the environment for agriculture are opposite to the belief of adapting to nature's circumstances. Adapting the crops, rhythm and other activities to the seasons and floods was not general. Yet, throughout history these means have without time, even if barely present, and are even on a return. The rising interest in these adaptive means can be seen in urban, lowland areas such as around the Thai capital of Bangkok which have been a point of policy since the heavy 2011 floods.[31]

Wittfogel states that for irrigation, farmers were required to put in more effort than farmers dependent on rainfall. This demanded a radical social and political change in the specific geohistorical setting.[32] The water management of a newly agricultural society needed structure and leadership ultimately leading to the hydraulic societies. Wittfogel connected the hydraulic engineering to state building. Those who were able to control water were able to control people.[33] He saw a direct link between the development of states and water management. This line of thinking has been debunked several times, specifically in the case of Angkor Wat were there was no tie find between the artificial ponds and irrigation structures.[34] The idea however that a larger population due to increased rice productivity led to forms of social organization is not entirely implausible. Even when considering the unresolved debate about what the exact purpose of the moats and artificial lakes in Angkor Wat were.[35] Thus, Wittfogels reasoning of coercion and forced labour in return for water resources, does not add up, but

[26] K. Wittfogel, p 11.
[27] K. Wittfogel, p 13.
[28] K. Wittfogel, p 14-16.
[29] Recent research of Fletcher into the Angkor Wat complex has raised the point that the moats and the irrigation system were of ceremonial purpose. For more information check: http://sydney.edu.au/angkor/
[30] K. Wittfogel, p 21.
[31] W.S. Sophonpanich, p 16.
[32] K. Wittfogel p 17.
[33] K, Wittfogel, p11.
[34] R. Fletcher et al, p 660.
[35] R. Hamilton, p 381.

the practical aspects of rice-growing have certainly impacted the formulation of states as well as the other way around.[36]

The introduction of new varieties developed with modern technologies and new means of cropping could not reproduce relative similar levels of productivity that were produced during the times of the successful kingdoms. According to Morita, what makes floating rice special as opposed to irrigation, dams and other hydraulic infrastructures is it so-called 'elongation capacity'.[37] This capacity specifically means the capacity for the plant to grow quickly, keeping pace with the rising floodwater. Floating rice in this respect differs from manmade engineering, who cannot design the same elongating ability. In practice this shows for floating rice to be (and was) not just a part of the agricultural means of production but in the ancient kingdoms interwoven with the political structure, water management and infrastructure were deeply entangled.[38] Summarizing, from ancient times to modern day the rice cultivation in Southeast Asia has shaped the continent in social, economic, political and other means.

2.3 Mapping adaptation and rice cultivation

Where Ravesteijn sees technology as the key, Wittfogel finds a social and geographical factor. Both look at the events which led to increases in production. Ravesteijn focuses on changes in water management during the colonial era in Indonesia. Wittfogel focuses more on the transition from hunter-gatherers to settled farmers depending on rainfall and subsequent social organization. Only afterwards the transition is made to irrigated farming or otherwise manipulating circumstances. The more suitable ecological adaptation through manipulating water and crops is described in the works of Hanks. Hanks states in his book 'Rice and man' four means through which the transition of rice cultivation took place.[39] Transitioning between types of cultivation depended on the ability and knowledge of the farmer. The subsequent four means portray different features in terms of population that could depend on the cultivation, the level of impact on the direct ecology and the amount of labour required and the existing climate.[40]

All four means of cultivation can still be recognized in today's situation. Hanks defines the four means as; gathering, shifting cultivation, broadcasting and transplanting.[41] These four means are representatives of the relationship between rice, the cultivators and their environment. 'Gathering' is solely based on the forces of nature. The rice varieties grow among grasses in scattered and

[36] R. Hamilton, p 387.
[37] A. Morita, p 747.
[38] A. Morita, p 747, Ishii pointed this quality out as well.
[39] L. Hanks, p 25-39.
[40] L. Hanks, 'Rice and Man', 1972.
[41] L. Hanks, p 25.

unpredictable patterns. This form was mostly found in areas unsuitable for permanent living, such as tidal areas. Small groups could depend on the added value of the found rice to their diet.[42]

Shifting cultivation required people to be settled and for the cultivators perform a series of tasks to match the rhythm and characteristics of the environment. The slash-and-burn technique is the prime example of such shifting cultivation. New fields were required with each yearly cycle and nutrition was drawn from the soil in combination with rainwater for humidity. This type of cultivation was seen in areas from the Himalayan ridges until the coasts and concerned mostly dry rice. [43]

Broadcasting was a more intricate technique of fixed field rice cultivation. Cultivation had learned to respond to signs in the sky and earth and scattered seeds across the field on the opportune moment. This more complex set of techniques was associated with the terrain and condition under which the cultivators operated. The fields were still open and undyked, allowing water to freely enter and leave.[44] The prime example to broadcasting in Asia is around the Tonle Sap Lake in Cambodia, where farmers learned to read the annual floods and cultivate accordingly. Another example is the Chao Praya plain around Ayutthaya in Thailand.

Finally, the transplanting technique meant moving shoots of rice to fertile soil. This type concerned, even in its simplest form, the control of water. An example is natural flooding and water retention through diking. This technique required precision and an environment that was relatively uniform.[45] The lower Chao Praya basin, more towards the sea was potentially such an area. The village however in the focus of Hanks' research, Bang Chan, had not seen the level of sophistication that was required.[46] The main difference between broadcasting and transplanting in the case of Thailand was to the population density the type could sustain and the human energy and labour the type needs. Broadcasting can sustain less of a population but is also less labour intensive.[47]

Aside from the four types that Hanks identifies, the previously mentioned strategy of using the best variety of rice has been a major contributing factor to the relationship between the cultivator and his environment. In particular the type of rice that could withstand the flooding. Examples of rice varieties with such an ability were, for example, the high-yielding variety which was developed in Europe in the 19th century. This type could be planted in between floods and would grow faster than traditional rice and could be harvested sooner.[48] Another example is the variety of rice which was

[42] L. Hanks, p 25-28.
[43] L. Hanks, p 28-33.
[44] L. Hanks, p 33-36.
[45] L. Hanks, p 36 -39.
[46] Ibid.
[47] L. Hanks, p 165-166.
[48] L. Hanks, p 43.

more suited for the environment, such as floating rice. Ishii describes the spread of the 'slender' rice of the Indica rice family. In better known terms this rice is the lowland and floating rice variety.[49]

An added strategy to increase the cultivation of rice that is also suggested is multiple cropping. Multiple cropping involves the sequencing of crops grown on the same plot depending on the condition of water available.[50] With availability and retention of water, this strategy is particularly useful for the people living on the edge of the Tonle Sap lake. Around the lake, water is made available through the retention of floods and the crop sequencing takes the water level required for the crop into account.

In short, in terms of wet rice cultivation there are the four strategies of Hanks to be considered, aided by rice variety and multiple cropping. The relevant type of rice cultivation in this thesis always refers to wet rice cultivation. Wet rice cultivation knows four types; the first being irrigated cultivation. This is probably the most common method and includes transplanting young rice plants between fields. Second is rainfed lowland cultivation, third floodplain cultivation and fourth deep-water rice cultivation. The latter is also known for the floating rice varieties.[51]

2.4 Further considerations

On the flipside of historical development and adaptation, are the effects of modern invasive measures for water management. They, in relation to agriculture, are devastating. The environmental and sustainability component is becoming more and more important.[52] The global climate change, environmental impacts of dams and pressures on production have put a strain on agriculture and rice cultivation. The Tonle Sap lake has suffered from increases in extremities between seasons as has the Chao Praya basin. These negative events must also be considered in line with the adaptation and changes over time.

Aside from modern challenges, the important realization made is that large-scale production of rice did not begin until the arrival of the colonial powers. The colonial powers did bring changes in technology, monetary resources and the mobilization skills to create intricate water management systems. Hatcho et al. and Ravesteijn all see the development of rice cultivation in the delta's over Southeast Asia as growing exponentially after the colonial powers arrive in the 19th century.[53] Thailand, Cambodia, Vietnam and Indonesia each have major river deltas, basins and surrounding

[49] Y. Ishii, p 11 and p 13.
[50] L. Hanks, p 40.
[51] R. Hamilton, p 29.
[52] This is highlighted in the Facts Sheets of the International Rivers Organization, an example on the Lower Mekong Dams is available at: https://www.internationalrivers.org/resources/the-lower-mekong-dams-factsheet-text-7908.
[53] N. Hatcho et al, p 6 and 9.

lowlands. Hatcho et al. recognize a difference in philosophy between the West and Asia in how to increase the amount of land and agricultural productivity. [54]

Another factor to betaken into account, is the system in which rice was cultivated and the purpose of cultivation. In ancient times rice was cultivated as a means of sustenance. The grain was used for food and the stems could be used for roofing.[55] In modern Cambodia floating rice is still consumed by the rural population and a portion is used for making rice wine.[56] The purpose of rice as a crop for marketing stems from hundreds of years ago; in the Ayutthaya kingdom the surplus of the harvest was taxed by the ruler and subsequently marketed by the elite.[57]

In the end what made the difference for Asian lowlands, even before colonialism, was the adaptability of the peasant's farmers to the flood regime. Their use of the flood regime as well as rice varieties that were able to grow in deeper water made that civilization in the lowlands were able to flourish. As Hanks notes: *"Without the magnificent adaptability of rice and its responsiveness to man's nurturing, certain tropical civilizations – Golconda in India, Srivijaya in Java and the Khmer of Angkor in Cambodia- based as they were on riziculture, could never have come into being".* [58]

[54] N. Hatcho et al, p 11.
[55] A. Agarwal, p 59.
[56] J. Pittock, p 10.
[57] H. Ten Brummelhuis, p 33.
[58] L. Hanks, p 23.

3. The multidimensional story

"We often speak of 'producing food', but farmers do not produce the food of life. Only nature has the power to produce something from nothing. Farmers merely assist nature"[59]

This chapter will focus on the multi-dimensional background of the development of the Chao Praya basin and the Tonle Sap lake. Multi-dimensional means that the development that took place has been influenced by many factors. The adaptation to the lowland environment in the two regions is reflected upon in terms of the climate, culture, crop cultivation and other relevant dimensions which will help shed light on the adaptation strategies. Local differences in water, soil, climate, rice varieties and population are aspects that will be considered in this chapter. Altogether the considerations in this chapter will show that the adaptive nature of rice cultivation in Asia. This chapter will also provide the general outline for the case studies of chapter 4.

3.1 Climate, civilizations and ancient development

The Chao Praya basin and the Tonle sap Lake are both located in the tropical savanna. These climate conditions can be found parts of the African continent, Central and South America, Australia and parts of Asia. In Asia the tropical savanna climate influences parts of India, Thailand, Cambodia, Laos, Indonesia and Vietnam.[60] The climate is characterized by large variation between seasons, they know wet period and dry period. During the dry season the regions subjected to the climate may know periods of extreme drought.[61]

Noteworthy to the tropical savanna climate, is that in all continents there are regions subjected to the climate and in these regions, there have been successful civilizations. Sophisticated civilizations occurred in Mexico, India, parts of the Andes Valley and Vietnam. Examples are the Azteks in Mexico, the Tiwanaku in Bolivia, the Vedic-Aryan societies in the western-Ganges located in India and the Champa civilization in Vietnam. [62] The ancient civilizations all faced similar circumstances; fertile soil, sun exposure and enough water. Flood prone river basins made potentially good agricultural environments and the places where people were successful became subsequent centres of civilizations.[63]

[59] M. Fukuoka, p 17.
[60] Map, Koppen climate; The effect of climate on timescales of drought propagation in an ensemble of global hydrological models - Scientific Figure on ResearchGate. Available from: https://www.researchgate.net/Map-of-the-Koeppen-Geiger-climate-classification-used-in-this-study-TRO-W-tropical-wet_fig1_322212659 [accessed 1 July 2018]
[61] Ibid.
[62] Barton, map 16.1 shows examples of archaeological sites in Asia where some of these civilizations have been located.
[63] K. Wittfogel, p 20-21.

While irrigation was mostly reserved for upland areas, the lowland areas faced constraints in attempting anything similar. There were technical constraints on lowland damming, such as manpower, and other forms of water control. Other options had to be found, such as crop variety and style of cultivation. Potter et al. find that there is a varied pattern of using water resources and space. One of these resources was the intensive use of favoured locations for permanent cultivation, which also allowed for a high population density.[64] The Chao Praya and the Mekong basin, including the Tonle Sap lake, are part of the category of Southeast Asian mainland's river systems that allow for varied patterns in the use of the water present.[65]

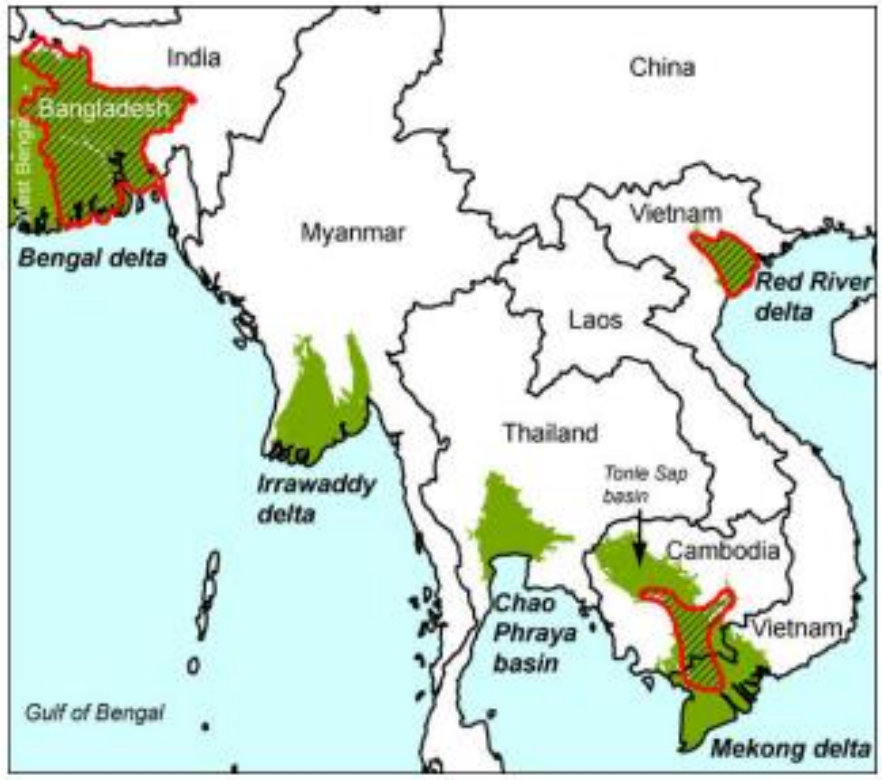

Fig. 1. Map of the Bengal delta and the major floodplains of Southeast Asia. The investigated regions of the Mekong delta (Cambodia and Vietnam), the Red River delta (Vietnam) and Bangladesh are highlighted with hatched shapes. Further As affected regions on this map are West Bengal, India (Chowdhury et al., 2000) and the Irrawaddy delta, Myanmar (Winkel et al., 2008a). The Chao Phraya basin is at low risk (Winkel et al., 2008a).

Figure 1, Lowland areas of interest in Southeast Asia[66]

Figure 1 shows the major floodplains of Southeast Asia. The Chao Praya basin and the Tonle Sap Lake are indicated in green. The other green areas are the Bengal Delta in Bangladesh (containing the Brahmaputra river among others), the Irrawaddy delta in Myanmar (also known as Burma), the Red River Delta in Northern Vietnam and the Mekong river Delta which crosses from Cambodia into

[64] R. Potter et al, p 242.
[65] J. Miksic, p 49.
[66] J. Buschmann, p 1279.

Vietnam. In each of these areas there has been rice cultivation for a long period of time. The Red River delta and Irrawaddy delta like the Chao Praya, Mekong delta and Bengal delta all subjected to the tropical savanna climate and cradle of ancient civilizations.

3.2 Agroecology and adaptation to the environment

Throughout time populations have adapted to their environment. From the pre-historical hunter-gatherers to highly sophisticated and very intricate civilizations. To this day the predominant mode of agriculture (particularly in Southeast Asia) is peasant farming operating in small family farms or independent peasant proprietors. This means that families own small plots, have land and work the land themselves without any hired labour.[67] Rice lends itself well to this specific form of agriculture. There, for example, is persuasive archaeological evidence that rice cultivation has been practiced in ancient Thailand; the Non Nok Tha excavations in the northeast of Thailand delivered remnants of rice grains which were cultivated on the mountain slopes.[68]

Morita states the relation between environment and agriculture as outcome has the infrastructure. In Morita's words: *"In this sense, these infrastructural inversions rather as endeavours to simply know infrastructure must be eliciting ontological experiments. Such infrastructural experiments reconfigure the relationships between farmers, rice, canals and water management practices. Over time, they have created and recreated the material and conceptual spaces of people and floating rice"* Ishii saw the ability to adapt to the floodplain environment by relying on floating rice as a similar development as irrigation in the uplands.[69] Floating rice was the biological, non-invasive method of coping with recurring floods and rising water levels. This is characteristic for the Chao Praya basin and Tonle Sap lake. Floodplain agriculture and rice cultivation were production methods in tune with nature. The move from the drainage region into the floodplain and later into the delta were a result of agroeconomic adaptation.[70]

How exactly the transition between environment and styles of agriculture as described by Hanks were made, is through developing traditional ecological knowledge (TEK). The knowledge was/is derived from the ecosystem and thinking about that ecosystem as an interaction and mutually enforcing, functional and adaptive unit.[71] The belief is that the knowledge attained is passed through generations at contains directions in management, classification, making observations and translations into skills and capabilities.

The local knowledge then becomes a means of harnessing the potential of the ecosystem. The process is both individual and collective, through activities and experimentation and the accumulation,

[67] D. Perkins et al, p 644.
[68] Y. Ishii, p 5.
[69] Y. Ishii, p 18.
[70] Y. Ishii, p 26.
[71] E. Phungpracha et al, p 83.

adaptation and transmission of the following experiences.[72] Through this process knowledge on rice cultivation was gained and applied through the means of cultivation, shifting, broadcasting and transplanting, each with its own set of skills and requirements. For illustration; the case of the Tonle Sap lake in Cambodia it must be considered that the primary source of change in the ecosystem is flooding. Accordingly, the features of the Lake's floodplain such as structure, quality and function are mostly influenced by flooding. Any human activity must be considered secondary in effect.[73]

3.3 Riziculture

Southeast Asia has a long history of 'riziculture'; the cultivation of rice. Rice is said to be domesticated as a crop outside of Southeast Asia. Some theories claim the cultivation of the grass-like plant came from southern China.[74] This is however not supported by archaeological evidence.[75] What is clearer is that rice was domesticated and not foraged by the hunter-gatherers in prehistoric times. Rice was grown as one of many crops in all areas.[76]

The introduction and adaptation of rice have been significant for the two areas are particularly interesting. The climate in the lowlands allowed for labour extensive cultivation and harvest. In Thailand and Cambodia rice was able to grow quickly over the season and gave high yields. It is the climate, which in the first place suited the plant to the population. Rice as a crop is significant because of the plant's adaptability to the environment. The plant can grow in many circumstances.[77] Without its adaptability many areas would not have been able to be used for the purpose of agricultural production.

The Chao Praya Basin and the Tonle Sap Lake are in the mainland Southeast Asian region, which is subjected to a monsoon climate. The monsoon climate is characterized by wet seasons and dry seasons. For both regions the dry seasons last between 5-6 months.[78] The dry season generally falls in the months of January to April (or June).

The Chao Praya Basin stretches from the north to the south of Thailand where it flows out into the sea. The floodplains are in the vicinity of the city of Ayutthaya, named after the kingdom of Ayutthaya, about a 100km upstream from the Thai capital Bangkok. The floodplain is about 2m above sea level. The river tide is subjected to large amounts of rainfall in the wet season which creates the conditions for perennial (reoccurring) flooding.[79] The variety of rice grown in the area was capable of

[72] E. Phungpracha et al, p 85.
[73] M.E. Aria et al, p 54.
[74] P. Boomgaard & Henley, p7.
[75] Hill, in Boomgaard & Henley, p 29.
[76] Ibid, p 37.
[77] L. Hanks, p 23.
[78] A. Reid, Critical Crossroads, p 35 of 520.
[79] A. Morita, p 739.

coping with the rising water levels and still grow. Due to this ability the rice was easy to grow and the profits from large scale cultivation the hub the city of Ayutthaya became.

The Tonle Sap Lake is therefore subjected to a different climate than the rest of the Mekong River Delta which is characterized by more rainfall and a shorter dry period of approximately 2-4 months.[80] The lake is influenced by the so-called 'flood pulse' system. This system is the reversal of flow from, and to, the lake in the wet and dry season. During the dry season water flows from the lake in the Mekong river basin, while during the wet season the water level may rise over 10 meters and expand the lake fivefold as the Mekong flows into the lake.[81] The Great Lake, Tonle Sap, is known for its biodiversity and unique water regime and the great seasonal variations in water level and volume.[82] The lake was in 2006 one of the most productive freshwater ecosystems, as well as one of the lakes with the biggest volumes of fish.[83]

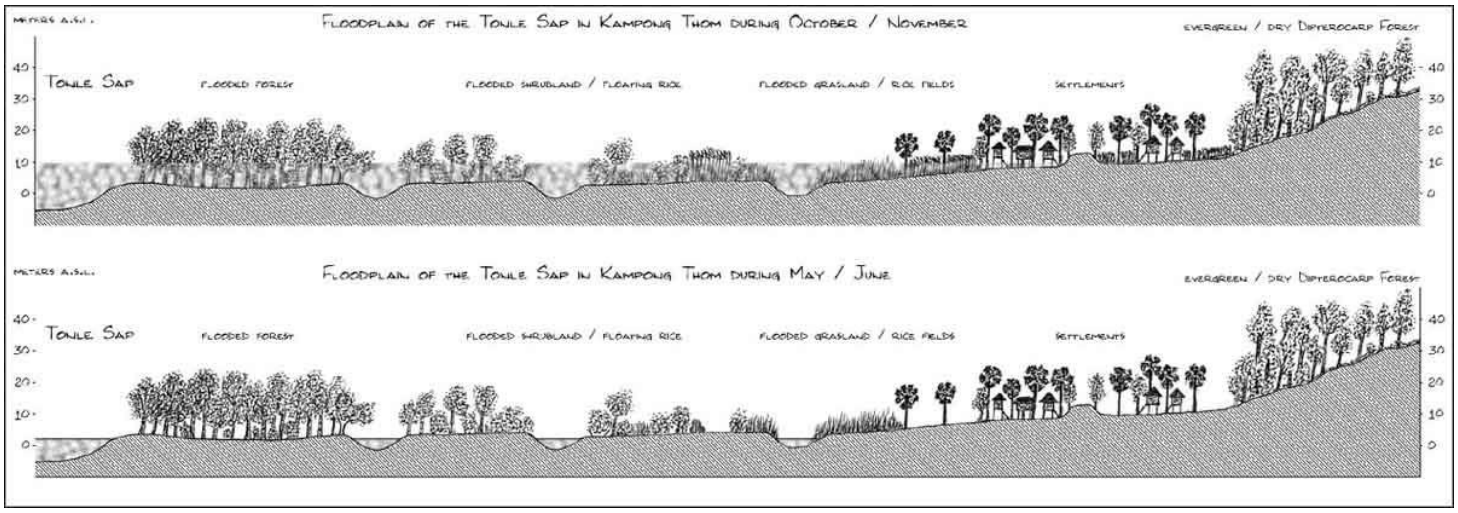

Figure 2, Floodplain of the Tonle Sap Lake during the wet season (above) and dry season (below)[84]

During the dry season in mainland Southeast Asia the land dries out in the deltas of the rivers, except for the land directly surrounding the great rivers. According to Reid the deltas provide optimal conditions for rice-cultivation. The soil becomes enriched due to flooding during wet season and is provided with a large enough amount of water to sustain multiple harvests. The area of the Tonle Sap lake is even doubled as the world's most productive freshwater ecosystem.[85] Figure 2 displays the floodplain around the lake during wet and during the dry season. The figure clearly shows the difference in water level and the reach of the water as a result of the increased water volume in the

[80] A. Morita, p 739.
[81] J. Fox, p 38.
[82] M. Keshinen (2006), p465.
[83] M. Keshinen (2006), p 466.
[84] Halwart, figure, FAO report.
[85] M. Keshinen (2007), p 49.

lake. Furthermore, the figure illustrates the separate sectors; flooded forests, flooded woodland/ floating rice, flooded grasslands/rice fields, settlements ad evergreen/dry forests.[86]

Since the 16th century surpluses were gathered by growing a large variety of rice which could grow as tall as the water level rose; an estimated two to three meters a year. In Thailand several varieties of rice were sown throughout the year; a rice was sown in the lands where water was subsiding during the months of November and December and could be harvested in March. Fast-growing types of rice were planted in March and harvested in June.[87]

Because of the rising water levels in the floodplains during the wet seasons the areas were at first not very inhabitable. The areas were mostly characterized by a form of flood retreat agriculture; where the population would retreat to upland areas during the wet season and cultivate the lowlands during dry season. Along the riverbanks settlement was easier and less prone to risk of flooding. Because of this most of the dense populations were located along the riverbanks before the 1800's. The type of plants cultivated added to the complexity of Southeast Asian early agriculture. Large diversities not only in rice varieties but also crops such as taro, banana and even sugar cane were woven into the agricultural societies.[88]

Around the fourteenth century the Ayutthaya kingdom emerged in the southern part of Thailand along the banks of the Chao Praya river. This kingdom took flight in terms of foreign trade and large-scale cultivation of rice. Rice was argued to have been a source of taxing the population.[89] Population centres grew consequently even more because of the rice agriculture and strong rulers. The Ayutthayan King is often credited for his policies regarding trade and rice. Rice as a crop not just part of the history of Thailand and Cambodia, the crop currently is a large part of the agricultural production. In Thailand the agricultural export in 2010-2011 was calculated by the Asian Development Bank to be 13.3% of the nation's GDP. Rice cultivation was the main crop of agricultural cultivation in the lower basin of the Chao Praya.[90] There is also a component of how the crop shaped the population that cultivated it.

3.4 Culture, Language and rice

The learning process described previously of individual and collective learning through experience, also translated into culture and religion. People learned how to work different soil types and crops while considering factors such as water regimes, weather patterns and seasonal cycles. These were then further rendered into collective rites and rituals. Rice has not just become a staple in the diet but also the bearer of culture and myth. Many of the rituals, deities and feasts would coincide with certain

[86] Halward, figure, FAO report.
[87] P. Boomgaard, p 230.
[88] Y. Ishii, p 23.
[89] Y. Ishii, p 11.
[90] P. Nara et al, p 138.

turns in season or points in the growth process.[91] The seasonal cycle of growth and harvest of rice was seen for example as an expression of Yin and Yang in the Chinese culture.

The Chao Praya basin is mainly inhabited by the ethnic Tai. This language group spreads from halfway to the Malaysian peninsula up to the north of Vietnam and Southern China. Along the shores of the Salween river all the way to the west bank of the Mekong river. The Tai speaking groups is the second largest language group in Southeast Asia and was spread through the dispersion of upland rice agriculture.[92]

In the seventies when Hanks wrote his book on Rice and Man, the central plain of the Chao Praya has an estimated of 520 persons per square mile.[93] The Thai people he writes about consider rice the staple of their diet, the main ingredient upon which other condiments and dishes are heaped. Hanks even provides the example in the Thai case of rice being at important moments in the world's story between the forming and dissolution of the universe. It is even believed by the villagers that rice makes the body of man, sustain man and healing man.[94] Both Thai and Cambodian language have distinct words and term to describe the set of complex techniques and skills associated with the cultivation of rice terrain and conditions to watering the crop. The Thai for example have the word 'naa waan' and in similar fashion 'srauv prous' is used in Cambodian.[95]

Cambodia, like Thailand, is a country in mainland Southeast Asia and still one of the poorest in the region. The current estimated percentage of 70% of the labour force working in agriculture and fishing.[96] Over a million people live in the direct vicinity of the lake and within the floodplains.[97] The number of people living in the floodplains these days, the area submerged during the wet season between 0m and 8m above sea level, is estimated at 140,000. The region of the Tonle Sap Lake and the lower Mekong river was inhabited by the Khmer (Reid; Mon-Khmer (Austro-Asiatic)). Between the Tai and Khmer there have been exchanges and instances where both ethnic groups gained knowledge or had conflict. For a period, the Khmer controlled the Tai population and influenced them in terms of religion, culture and city planning Borrowed technology for irrigation, water retention and canals took place.[98]

Both the Tai people and the Khmer ethnic groups are rice-growing societies with their own belief. Hamilton provides a list of twenty tenets that rice cultures possess. In these tenets some distinct characteristics are mentioned that occur in either Tai or Khmer culture, in both or in many other rice

[91] E. Phungpracha et al, p 85.
[92] A. Reid, p 45 -520.
[93] L. Hanks, p 5.
[94] L. Hanks, p 21-22.
[95] L. Hanks, p 35.
[96] M. Keshinen, 2007, p49.
[97] Ibid.
[98] N. Hatcho et al, p 8.

cultures. For example, the divinity of rice, the stages of rice-growing being determining the human cycle, mythological attribution such as a Rice Goddess, special attention to granaries and protective spirits. Other illustrations are the presence of multiple words relating the cultivation and plant.[99] The English phrase 'to eat' has its Cambodian equivalent in the phrase 'pisa bei' which literally translated means 'eat rice'.[100]

[99] R. Hamilton, p 30.
[100] H.J. Nesbitt, p 1.

4. Case Studies; development over time

"Since human life depends on rice, the fertility of the rice crop and the fertility of humans are one and the same"[101]

This chapter will contain the illustration of the adaptation of rice growing societies throughout the ages. The chapter contain two separate case studies, one into the Chao Praya basin and more specifically the Central Plain in Thailand. The other one is about the Tonle Sap lake and the surrounding area in Cambodia.

4.1 Introduction

In the agricultural development and rice cultivation there are a couple of important periods over time, such as the empires; both the Chao Praya basin and the Tonle Sap lake have sustained large pre-industrial and pre-modern empires. These empires were rooted in the flourishing agriculture which was manifested in the style of flood retreat agriculture and deep-water rice cultivation. These days, the empires have disappeared, but people have continued to live in the areas and are still cultivating rice.

In the early settlements, the Tonle Sap's link to the Mekong river and the Chao Praya river in Central Thailand would arguably have been principal means of communication, exchange of goods and linking settlements. All this through the proximity of flowing water. [102] Higham describes the major turning point in Southeast Asia around the 5th century BC. Around this time external influences came from the North; the first rice farmers, exchange of specialist movements along the rivers, and the ability to cast bronze. [103] Reid recognizes an age of commerce of Southeast Asia from 1490-1640. During this time Southeast Asia was a world hub and a centre of commerce and trade. This era was propelled by the Chinese and Europeans being interested in natural resources such as silver and spices.[104] From the 1950's the construction of dams skyrocketed, and the area of land used for irrigated agriculture grew accordingly.[105] Around 2010 the Chao Praya basin was considered the main producing region for rice due to its advantage in the scale of productivity of the land, the advanced technology and, where used, the sophistication of the irrigation systems.[106]

The above events are only a small illustration of the developments the two regions have seen through the ages. In terms of economy, population and politics the regions have changed. Rice cultivation

[101] R. Hamilton, p 377.
[102] C. Higham, p 35.
[103] C. Higham, p77.
[104] A. Reid, p 107.
[105] R. Potter et al. P 234.
[106] P. Nara et al, p 138.

however, has remained a central part to the story. Hence this chapter will demonstrate the changes in the Chao Praya basin and around the Tonle Sap lake.

4.2 Chao Praya basin, Thailand

The Chao Praya river is one of the older rivers in Asia. While the river is not as long as the Salween, Mekong and Red River, the Chao Praya is considerably shorter and springs from the lower though geological older hills.[107] The central plain of Thailand is mostly under the influence of the Chao Praya river. The river flows for about 372 km and leads into the Gulf of Thailand. The area around the river is the home to the oldest as well as the most populous settlements.[108] Between 1953 and the 1970's the population grew from 422 people per square mile to an approximate 520.[109] The Chao Praya Basin has a long history of successful rice cultivation in the floodplains of the river. Varieties of floating rice were able to grow as the water level rose reaching up to 3m.[110]

4.1.1 Ancient times

The Chao Praya has been the mother of most of Thailand's ancient capitals; for example, the Singburi during the Angkor period and later for 416 years the Ayutthaya city.[111] The Central part of Thailand also contains several ancient Neolithic settlements. The Neolithic age is highlighted by wat is called the 'Bronze Age'. Neolithic sites in South and Southeast Asia roughly date between 8,000 BC and 2000 BC. These settlements contain burial grounds of people living in the area at the time. In terms of activities and language the first words for rice and rice cultivation have been found.[112]

From the Neolithic period the population in Central Thailand grew. A historically significant era in the Thai development was during the Ayutthaya Kingdom. Located in Central Thailand the city of Ayutthaya is at the heart of the Chao Praya river basin. About 70 kms from the current capital Bangkok. This Kingdom managed to grow exponentially and become a regional hub for trade. The city was connected to the sea by a belt of mud in the delta and the river which contained two separate ports; Sukhothai and Lopburi.[113] It was supported by low cost, high yields in agriculture which allowed for surplus to be taxed internally and marketed externally. The commercial nature of the cultivation is considered like that of European medieval cultivation purposed and strategies.

While the Chao Praya basin has seen the digging of canals, these were arguably not for irrigation purposes. Rather they cut the travelling time for transportation of good by going straight instead of

[107] L. Hanks, p 3.
[108] World atlas, https://www.worldatlas.com/webimage/countrys/asia/thailand/thland.htm (accessed 27-04-2018)
[109] L. Hanks, p 19.
[110] Y. Ishii, p 26.
[111] J. Miksic, p 50.
[112] C. Higham, p 45.
[113] Y. Ishii, p 27.

following the meandering river. Along the canals and other natural elevated spaces, the population lived in houses built on posts.[114]

From the thirteenth up to the fifteenth century the Chao Praya basin witnessed a momentous transition in rice cultivation. Within the central plain of Thailand there was a transition from upland shifting to cultivation to broadcasting cultivation in the lower lands.[115] The kingdom of Ayutthaya was under French influence from 1683 to 1688 but was not further colonized.[116] In 1767 the kingdom toppled, and the capital was moved from Ayutthaya to Bangkok. During this period there was a notable transition from commercially aimed cultivation to a 'plantation-type' cultivation. This style of cultivation aimed more towards large-scale production of agricultural produce for export.[117] No longer a by-product of commodity trade as a surplus but cultivated and marketed with the purpose of export. While the Kingdom of Siam was not colonized like neighbouring countries such as Vietnam, Cambodia, Indonesia etc. From 1850 to 1890 were the years through which fields and canals were created in the basin. This period led up to a period of broadcasting rice cultivation from 1890 up to 1935. The kingdom of Siam had trade relations with the Dutch, British and French who had an interest in the rice and other commodities.[118]

A nice illustration of the attempts of transforming the system of water management and rice cultivation in Siam are the attempts of Homan van der Heide. Van der Heide was a Dutch engineer who spent six years in Siam, from 1902-1909. He is credited to be the creator of the Royal Irrigation Department and his main project had been a proposed plan for irrigation works in the Chao Praya basin.[119] Problems van der Heide encountered, in his mission to establish the system for irrigation as part of an agricultural policy, were both political and cultural. The Siam elite prioritized railway building and maintaining relations with the British Financial Advisor. They were not very keen on providing funds for the projects for there was little monetary return. Ten Brummelhuis believes the character of van der Heide as a possible added impediment, which was unmoving and apparently rigid.[120] In the end the vision of van der Heide was realized fifty years after his departure in the 1950's. Arguably for various reasons. One of them was mentioned to be that the country had not been ready before and his vision timed too early for Thai capability to transform in that direction. Private ownership and the prioritizing of irrigation for the government finally made way for changes to the floating rice systems.

[114] Y. Ishii, p 28.
[115] Y. Ishii, p 9.
[116] J. M. Pluvier, map 44.
[117] Y. Ishii, p 33, 38.
[118] H. ten Brummelhuis, p15.
[119] H. ten Brummelhuis, p 1.
[120] H. ten Brummelhuis, p 346.

4.1.2 Post-Colonial and modern times

Post-colonial and modern times focused on the increase of productivity. Through increases in the use of fertilizer, farm mechanization, new varieties that were developed and different cultivation methods.[121] While Thailand was never really colonized the spirit of colonial expansion and trade were of influence for the developments within the country.

In 1957 a dam was built in the Chao Praya river with the financial support of the World Bank. The dam has changed the entire basin dramatically, with the dam as the focal point of an irrigation systems which provides the basin with water.[122] The irrigation system doubles as a drainage network. The shift in system has created problems for the lower part of Thailand Bangkok which has started to experience flood problems, unlike before the dam. While the Dam in the river has positively influenced conditions for modern agriculture and rice cultivation in the highlands and upstream areas. What is an interesting development is the spatial shift in the use of the traditional Thai rice cultivation method of floating rice.[123]

The Green Revolution of the 1960's took place around many countries in Asia. South-Korea managed to increase agricultural productivity. The focus of the Green Revolution was in the implementation of newly developed sets of technology; High-Yielding Varieties (HYV), chemical fertilizer and modern structures for irrigation. A shift away from the aim of universal agriculture set forth in the 1960's Green Revolution came in the 1970's. This era was highlighted by more locally focused development and recognizing varied forms of agriculture specifically adapted to the local environment.[124] It became apparent that in certain regions in South, Southeast Asia and Africa that the uniform use of HYV's was could not easily be adapted to the lowland environment. In order to adapt the lowland areas to the HYV's there would have to be massive infrastructural investments.[125]

The increased concerns about the flooding in the Chao Praya estuary, in the nineties led to more recognition for the traditional means of coping with flooding while still maintaining productivity; floating rice. (specifically, around 1999). At the end of the nineties the lowest lands around Bangkok were appointed as water retention areas in the flood management policies regarding the Thai capital. In these lowest lands floating rice was a tool to retain the water and protect the city.[126]

Hanks already describes the views of floating rice to be fewer than once was than before the 1970's. Hanks reported in the early 1970's that in the Thai Central Plain approximately 520 persons per square mile lived.[127] The research of Hanks focused on the small town of Bang Chan, located to the

[121] Y. Ishii, p 305-310.
[122] A. Morita, p 744.
[123] A. Morita, p746.
[124] A. Morita, p 747.
[125] A. Morita, p 747.
[126] A. Morita, p 746
[127] L. Hanks, p 5.

North East of Bangkok.[128] The Chao Praya basin has also suffered from global warming which directly influence increased temperature, changes in rainfall, preservation of water and soil fertility.[129] Thailand saw a major flood during the 2011 monsoon season, one that impacted the Thai agriculture and rice production. The northern and central region of Thailand were hit by heavy rainfall and on top of that the government lacked capability to control the drainage and retention systems to cope with the water.[130] Government officials in Ayutthaya testified that the 2011 floods damaged the rice cultivation areas for the flood warning systems did not operate properly. Also, there was a lack of clarity and execution of the flood coping and prevention plans. As a result of the floods there has been a focus again on flood prevention and coping mechanisms. Proposed solutions are crop diversification, improvements in crop varieties, improvement of water retention resources and re-evaluating drainage systems.[131]

Other aspects Thailand has been facing throughout the country since in the last decades, are insecurities in production. The Green Revolution focused on generating higher yields through new technologies on the traditional farms. The Revolution has been criticized, however, in causing environmental damage. Farmers in Thailand are said to have become dependent on fertilizers and other enhanced additions to sustain the level of productivity.[132] Some scholars have argued of bringing back old techniques and local knowledge in favour of creating food security. The floating rice requires a small amount of input compared to the output and can withstand the multiple stress environment. The high-yielding bred varieties are not suited to all farming conditions, unlike the more traditional types of rice.

4.3 Tonle Sap Lake, Cambodia

The Tonle Sap Lake is located in Cambodia. The lake's unique characteristics have been significant in the rise of the Angkor civilization. The Lake is the central resource for food production in Cambodia, providing for fish, rice and other produce. The Lake is the largest fishery complex in the country and most of the country derives it source of protein from the lake.[133] In the previous chapter several of the seasonal characteristics of the lake have been mentioned. This section will provide a timeline of the development, changes and adaptation in cultivation. From ancient times until the modern age.

The Tonle Sap Lake is often called the 'heart of the Mekong' with a population dependent on the lake for their livelihood. From fishing to agriculture and these days tourism as well, the lake provides for the population living on its borders, in its floodplain and on the surface of the lake itself.

[128] L. Hanks, p 6.
[129] P. Nara et al, p 136.
[130] P. Nara et al, p 138.
[131] P. Nara et al, p 140.
[132] E. Phungpracha, p 83.
[133] M. E. Arias et al, p 53.

The Tonle Sap lake is often divided into sectors by scholars for appropriate research. Arias et al for example divide the lake into 5 sectors on the basis of flood regime and human activity; 1 – open water (flooded for 12 months a year), 2 – gallery forest (9 months average flood duration), 3 – seasonally flooded habitats (5-8 months and dominated by shrub- and grasslands), 4 – transitional habitats (1-5 months, dominated by abandoned agricultural fields, floating rice and receding grasslands), 5- rainfed habitats (1 month and consisting of wet rice fields and village crops).[134] Rice is mostly cultivated in the flat areas of land where water retention or some sort of irrigation are possible. The largest concentration of rainfed lowland rice is found on the banks of the Tonle Sap lake and the Mekong river. Figure 3 illustrates the major rice areas in Cambodia. The figure depicts the lake as well as the areas were deepwater rice is the main form of rice cultivation. The deep-water rice is concentrated around the lake for these are the lowlands.

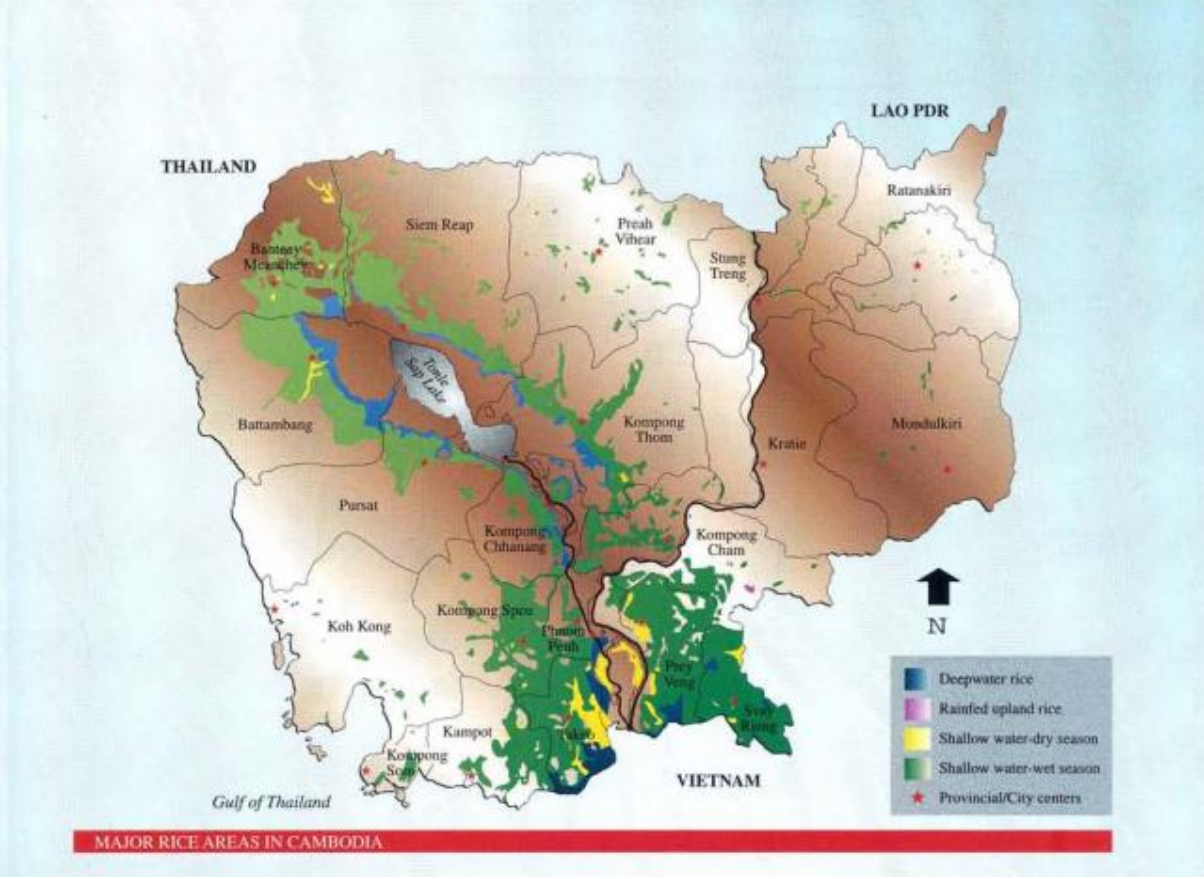

Figure 3, Major Rice Areas in Cambodia (approx. 1997)[135]

4.2.1 Khmer Empire / Angkorian Civilization 790 – 1431

In the period between 550 AD and 800 AD, the period for being known as Chenla, was the age of the birth of major temple sites around the Great Lake. One of the largest temple complexes can be found along the shores of this lake; the Angkor Wat temple complex. The Temple of Shiva contained many

[134] M.E. Arias et al, p 53.
[135] H.J. Nesbitt, p55.

scattered buildings and pools. The accounts from Chinese records describe the enormity of the site and the architectural successes of the early Khmer. During the Khmer period most of the ancient Cambodian population, lived in the area around Tonle Sap. North of the lake the land slowly slopes and rises gradually. Khmer people lived and between the Khorat plateau to the North and Tonle Sap.[136] During this period the lake became of importance to the Khmer society and was the basis for its large agricultural and irrigation network.[137]

During the Angkor-period flood-retreat or flood-receding agriculture was practiced around the Tonle Sap lake. Van Liere describes this type of agriculture as farmer use the annual incursion and retreat of water from the Mekong-river and its tributaries.[138] This type of activity was limited to agriculture. Any means of irrigation of sophisticated water retention were not used for the purpose of agriculture. It is the argument of Van Liere, as well as Fletcher, that the system of canals, ponds and moats around the temple complex of Angkor Wat was used for ceremonial and religious purposes.[139]

Somewhere between the 15th and 17th century the area around Angkor Wat was deserted by the population. Most of the area in Khmer control was transferred to Vietnamese rule in 1626. After the loss of Angkor Wat, the Cambodian capital was moved to Phnom Penh where it has remained. After the 17th century rural life and rice production in the country were subjected to war, violence and conflict between the ethnic groups in the region. later rebellions were directed and fought under French colonial rule.[140]

4.2.2 Colonial times

Cambodia, unlike Thailand, has been under direct colonial rule. The south of Cambodia was colonized by the French in 1863. The north of the country was colonized by the French for a period of two years from 1902-1904 but later released as a neutralized zone according to a Thai-French treaty from 1893.[141] The Tonle Sap lake was therefore partially under colonial rule and part neutral zone. During the French colonial rule, the period between 1900 and 1941 was the only time that the European country systematically implemented an agricultural development policy.[142] Development in this sense means a focus on increased productivity with the purpose of trade. The policy plan of the French consisted of two strategies; firstly, a large-scale plantation system using the most modern techniques and rice varieties propelled by hired labour. This also included the creation of irrigation canals for water management, infrastructural adjustments to increase the accessibility and transfer of the harvest. This system focused on quality rice for French and foreign markets.[143] This strategy was

[136] J. Miksic, p 48-49.
[137] M.E. Arias et al, p 54.
[138] P. Boomgaard, p 227.
[139] W.J. Van Liere as mentioned in P. Boomgaard, p 227 and R. Fletcher et al, p 660.
[140] H.J. Nesbitt, p 1 -2.
[141] J.M. Pluvier, map 44 and corresponding text.
[142] K. Helmers, p 1.
[143] Ibid, p 2.

implemented in the Battambang province, roughly to the North-East of the Tonle Sap Lake. The second strategy was directed towards the remaining Khmer peasantry. Rice cultivation was still according to traditional methods and varieties and on a smallholder farming basis. This part of the controlled agriculture was directed towards peasant sustenance. The French derived their revenue from taxing the rice. Also, unlike the other strategy, no investments were made directed at technology or infrastructure.[144] The concentration of this strategy was in the direct vicinity of the Tonle Sap lake.

Interesting is that Helmers records that during the implementation of both strategies around 16.000 hectare was used for the first strategy while between 0.5 and 1.5 million hectares were left to the peasantry.[145] The Khmer population at large was able to respond to market demands, both internally and for export. In the view of Helmers this coincided with the relatively peace and stability under colonial rule and the improvements in healthcare.[146] Cambodia gained independence in 1953 and up until the sixties received funds through westerns foreign aid programs which again focused on high yielding varieties and other new technologies such as national water control, irrigation, canalization and building dams and barrages.[147]

4.2.3 Post-colonial and Modern day

In the 1960's before the dictatorial regime of Pol Pot, the deep-water rice variety (or floating rice) occupied an estimated 16% of the total area where rice was grown in Cambodia. This equals about 400,000 hectares. Areas where this type of rice was grown at the time, were in the floodplains around the Tonle Sap lake in the Kampong Thom, Banteay Meanchey areas and the Battambang Province.[148] During Pol Pot's regime the areas where floating rice was cultivated decreased because of discouraging government policies. Since the end of the regime floating rice production, especially to the west of the Lake, has increased fast for it is essential for the local food security and source of livelihood.[149] During the regime Cambodia slumped from being a major rice exporter to hardly present on the world market and even its own nationals had very little to eat.[150]

Rice production in the greater Mekong Delta has seen a rise in production from 1955 to 1975 because of high yielding varieties and other technologies that were introduced during the Green Revolution. This advancement in technology alongside improved transportation and infrastructure for irrigation propelled the development. Smallholders farmers profited from a tenure established through land reforms. Cambodian, since decolonization and communism, internal developments have been slow.[151]

[144] Ibid, p 3.
[145] K. Helmers, p 2 – 3.
[146] Ibid, p 4.
[147] Ibid, p 4.
[148] Y.T.B. Nguyen et al, p 44.
[149] Y.T.B. Nguyen et al, p 45.
[150] H.J. Nesbitt, p V.
[151] O. Sjoberg, p 495-496.

In the late 1960's the areas around the Lake that were used for deep-water rice cultivation amounted to about 400,000 hectares, which is approximately 16% of the total Riceland in Cambodia. [152]

Between 1995 and 2000 differences in land use and land coverage in the upper area of the flood plain were visible. Settlements had grown over this period in a 146% and an 18% increase in wet rice fields. The latter of the two was due to reutilizing abandoned fields. However, there was also a decrease in floating and receding rice fields around the lake by a measured – 63%.[153] Another interesting development in the floodplain around the Lake is the expansion of village crops and traditional rice paddies. Since the 1970's floating rice fields have been steadily abandoned and some twenty years later converted into rice paddies. This can be explained by the economic expansion and the population growth which have been ongoing since the long period of civil conflict in the country came to an end.[154] An estimated 4-7 % of cultivated areas was used for deep-water rice cultivation in the eighties.[155] A study by the Mekong River Commission showed the impacts of several future scenarios for the Tonle Sap lake. The study found that there could be a decrease in the depth of flooded areas. During the dry season this would amount to between 0.2-0.6meter and 0.5 m during the wet season. This means that the area used for rice fields could decrease by 300 to 630 km².[156]

Keshinen's research in 2006 called the socio-economic situation of the Lake diverse. Due to the nature of the ecosystem around the Lake the area has seen massive ongoing growth in population as well as poverty and a heavy dependence on the lake's natural resources.[157] The area holds a high ethnic diversity, seasonal variations of sources to maintain livelihood, unequal access to certain resources and a lack of property rights that increase uncertainty and poverty. The study by Keshinen showed that the people that depended on agriculture the most were living in the rural zones that were relatively far away from the lake.[158] The farmers face population growth causing a smaller availability of land and changes in the extremities of the seasonal flooding. Although these peasant farmers were generally found to be a bit wealthier than their neighbours who lived closer to the lake. Out of the population living around the lake the most of them are dependent on agriculture, with fishing as a secondary source of income.[159] Whether agriculture or fishing, the population of the Tonle Sap Lake is dependent on the seasonal cycle of flooding. Within the Mekong river basin, many farmers have experienced water shortages due to severe seasonal changes.[160]

[152] H.J. Nesbitt, p 69.
[153] M.E. Arias et al, p 60.
[154] M.E. Arias et al, p 62.
[155] H.J. Nesbitt, p 69.
[156] MRC (2010), M.E. Arias et al, p 54.
[157] M. Keshinen, 2006, p466.
[158] M. Keshinen, 2006, p472.
[159] M. Keshinen, 2006, p 472-473.
[160] E. Phungpracha et al, p 83.

The overall production of rice in Cambodia compared to the rest of Southeast Asia is at a lower level. Average yields account t 3.0 tonnes per hectare. Even though production has expanded, and Cambodia has become an exporter of rice, many rural household are forced to buy extra rice for personal consumption some time during the year.[161] The prognoses for lowland rice farming productivity around Cambodia vary. Between different studies and scholars, the productivity is thought to decline due to increased temperatures and increased flooding.[162] The people around the Lake also face increased uncertainty. If their harvest fails most move into the fishing which in turn is pressured. The livelihoods of the people around the Lake are endangered.

The Food and Agriculture Organization (FAO) recognized during its 19th session the trends and prospects regarding fish and rice-based farming. This symbiotic means of sustaining livelihoods and the varieties of animals and plants has been central to the study by the FAO. The FAO in their conclusions found that the entire ecosystem of rice fields in the Tonle Sap vicinity is of importance to the development of the region.[163] The focus on ones-sided development through intensification of rice cultivation is insufficient for the local population. The FAO recognizes: "*A more promising approach seems to be a participatory development approach that addresses all the needs of the local people through locally developed natural resources management plans and a more holistic view of a system that has catered the needs of the people for many generations.*"[164]

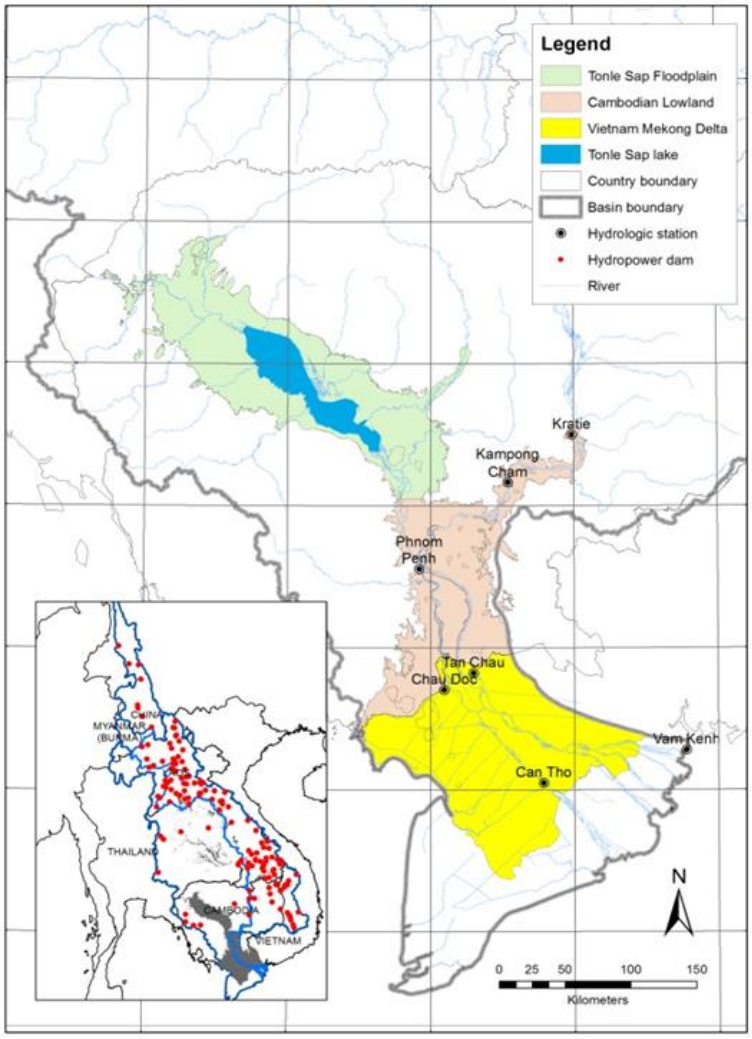

Figure 4, displaying the dam development in the Upper Mekong river. These damming projects ultimately will influence the water levels within the Tonle Sap lake.

Another development for the people around the Lake will be the expected changes in the flood pulse. Water infrastructure development,

[161] P.L. Poulton et al, p 160.
[162] P.L. Poulton et al, p 161.
[163] FAO, http://www.fao.org/docrep/006/y4751e/y4751e0n.htm, (accessed 14-05-2018)
[164] Ibid.

namely the planned dams in the Upper Mekong River, are expected to shrink the degree of variation in water levels between seasons; elevating water levels during the dry seasons and contracting water levels during the wet season.[165] This development reduces the potential for seasonally flooded areas. See figure 4 for hydropower development in the Mekong river basin and the calculated effects for the Lake. The figure displays the infrastructure and damming projects in the (Upper) Mekong River.

Future developments around the lake will be monitored and developed by the Sustainable Rice Platform (SRP). This multi-stakeholder platform was founded in 2011 and supported by the UN Environment and the International Rice Research Institute. This platform deals with the supply chains in the global rice sector and would be able to provide for a multi-faceted solution to the changes.[166] Another organization looking into the region in the Mekong River Commission and the International Rivers organization.

[165] M.E. Arias et al, p 63.
[166] www.sustainablerice.org, here the Background Document to their Sustainable Rice Platform (SRP) Performance indicators of 12 November to 11 December 2018 can be found here: http://www.sustainablerice.org/assets/docs/Background%20Document%20-%20Performance%20Indicators.pdf

5. Conclusion

"Precious things are not pearls and jade but the five grains, of which rice is the finest" – Chinese Proverb

To recall the main question of this thesis is: How did the adaptive style of rice cultivation affect the rise and development of lowland regions in Southeast Asia? This thesis has aimed to show rice cultivation and ecosystems as a dynamic and complex relation between plant, creature and environment. The interaction and interdependence make the whole a functional and adaptive unit.

The modern-day beliefs mentioned in the first chapter about agriculture by damming, curbing river flow and large-scale irrigation appear to be no longer be sufficient, both in historical and future perspective. The argument that lowland agriculture did not develop before colonialism, has been countered by showing that people slowly moved into lowland areas and developed means of cultivating crops, rice. Hanks provided four means through which lowland population could sustain itself; Gathering, shifting cultivation, broadcasting and transplanting. Thus, aside from water management the adaptation of crop and method of cultivation allowed from early development and increases in productivity. The full story is therefore much more complex than simply suggesting the bureaucracy, manpower, funds and sheer force of the colonizers created development of agriculture in the lowlands in Southeast Asia. The unique ability of rice to mould itself to the ecological circumstances provide a basis for success. Many varieties of the plant allowed for even better strategies. The deep-water rice cultivation became embedded in the environment as well as in the culture.

Both the Chao Praya basin and the Tonle sap lake adapted by understanding their environment and styling their agriculture accordingly. The means of production as suggested by Hanks in combination with varieties of rice that could withstand changing water levels, multi-cropping and becoming more knowledgeable and more efficient cultivators in the regions were able to survive. The tropical-savanna climate provided an excellent basis for the lowland agriculture. It could be depended upon to have wet and dry period. Adding to the equation the potential fertile soil and the basis for cultivating crops are available.

The Tonle Sap lake has been demonstrated to be a unique ecosystem which required a specific strategy for cultivation. As Arias et al state the hydrological, ecological, nutritional and cultural value that the Tonle Sap lake provides to the country of Cambodia cannot be denied. There are few other countries in the world that are this dependent on a single ecosystem as Cambodia.[167] The region has

[167] M.E. Arias et al, p 54.

seen rises and drops in productivity as a result of conflict, shifting capitals and extremities in the climate but has always retained a measure or sustained deep-water rice cultivation.

The Chao Praya basin, or central plain of Thailand is the home to much of the Thai population. The ancient canal systems are still visible today. In recent times the area has suffered from climate change and upstream river damming. Interesting to note is that Nguyen et al propose several measures to be taken in favour of increasing productivity. They propose to make prediction on the expected rainfall and water level, engaging in alternative cropping and improving on the elongation capacity of deep water rice.[168]

All in all, the adaptive style of rice cultivation was developed very early on in the two researched regions. Both regions display similar circumstances in terms of climate and strategies of adaptation. The utilization of a versatile crop as rice has been a key feature of being able to live in the lowlands. By sustaining a diet, the population which settled in the lowlands were able to sustain themselves. Departures from the early adaptive style as a result of colonialism, changes in technology and changes in infrastructure did not fully eliminate the old ways. Even in some way's negative recent developments such as climate change that causes extremities such a heavy drought and floods, have caused scholars to argue once again in favour of traditional means.

The effect of adaptive rice cultivation through non-invasive and low-impact techniques has been a subject of the past as well as the future. In the past it allowed people with little tools and understanding their environment to sustain themselves through rice cultivation. In the future such techniques may be called upon again as a result of climate change and increased levels of flooding. For rice and riziculture have been part of the past, present and future of the lowland areas in Thailand and Cambodia.

[168] Y.T.B Nguyen et al, p 55.

6. Sources

Agarwal, A. and, Chak, A. *Floods, Flood Plains and Environmental Myths,* State of India's Environment – a citizen's report, no 3, Centre for Science and Environment, 1991.

Arias M.E, Cochrane T.A, Piman, T, Kummu, M., Caruso, B.S. and Killeen, T.J. *Quantifying changes in flooding and habitats in the Tonle Sap Lake (Cambodia) caused by water infrastructure development and climate change in the Mekong Basin*, Journal of Environmental Management, Volume 112, pp 53-66, 2012.

Barton, H. *Chapter 16 - Early Agriculture in Southeast Asia and the Pacific*, Cambridge University Press, pp 411-444, 2015.

Boomgaard, P. and Henley, D. *Smallholders and Stockbreeders*, KITLV Press Leiden, 2004.

Boomgaard, P. *A World of Water; rain, rivers and seas in Southeast Asian Histories*, KITLV Press Leiden, 2007.

Boserup, E. *Conditions of Agricultural Growth,* Routledge, 1965.

Brummelhuis, H. ten, *King of Waters,* Verhandelingen van het Koninklijk Instituut voor taal-, land-, en volkenkunde, Number 226, KITLV Press, 2005.

Brickell, K. and Springer, S. (editors), *The Handbook of Contemporary Cambodia*, Routlegde Handbooks, pp 99-169, 2017.

Buschmann, J. and Berg, M. *Impact of sulfate reduction on the scale of arsenic contamination in groundwater of the Mekong, Bengal and Red River deltas,* Applied Geochemistry, Volume 24, pp 1278 -1286, 2009.

Fletcher, R. *Chapter 11 - Low-Density Agrarian-based Urbanism*, in . Smith (editor), The Comparative Archaeology of Complex Societies, Cambridge University Press, pp 285-320, 2011.

Fletcher, R. Penny, D. Evans, D. Pottier, C. Barbetti, M. Kummu, M. Lustig, T. and the Authority for the Protection and Management of Angkor and the Region of Siem Reap(APSARA) Department of Monuments and Archaeology Team, *The water management network of Angkor, Cambodia,* Antiquity, Volume 82, pp 658-670, 2008.

Fox, J. and Ledgerwood, J. *Dry-season Flood Recession Rice in the Mekong Delta: Two Thousand Years of Sustainable Agriculture,* Asian Perspectives, Volume 38, No.1, pp 37-50, 1999.

Fukai, S. and Ouk, M. *Increased Productivity of rainfed lowland rice cropping systems of the Mekong region,* Crop and Pasture Science, Volume 63, Number 10, pp 944-973, 2012.

Fukuoka, M. *The Natural Way of Farming – The Theory and Practice of Green Philosophy*, Japan Publications Inc. , 1985.

Furukawa, H. *Coastal Wetlands of Indonesia, Environment, Subsistence and Exploitation,* Kyoto University Press, 1994.

Keat Gin, O. (editor*), Southeast Asia Historical Encyclopaedia R-Z,* Volume III, ABC Clio, pp 1146-1148, 2004.

Halwart, M. (FAO) Technical Officer, *Recent initiatives on the availability and use of aquatic organisms in rice-based Farming*, FAO Rome, Italy, 1999.

Hamilton, R.W. *The Art of Rice -Spirit and Sustanance in Asia*, UCLA Fowler Museum of Cultural History, Los Angeles, 2003.

Hanks, L. *Rice and Man,* Agricultural Ecology in Southeast Asia, Aldine Atherton, 1972.

Hatcho, N. Ochi, S. and Matsuno, Y. *The Evolution of Irrigation Development in Monsoon Asia and Historical Lesson*s, Irrigation and Drainage, Volume 59, pp 4-16, 2010.

Helmers, K. *Chapter 1 – Rice in the Cambodian economy: past and present,* in Rice Production in Cambodia by H.J. Nesbitt (editor), Cambodia-IRRI-Australia Project, International Rice Institute, pp 1-14, 1997.

Henley, D. and Schulte Nordholt, H., *Environment, Trade and Society in Southeast Asia,* KITLV Press Leiden, pp 120-132, 2015.

Higham, C.F.W. *The Origins of the Civilization of Angkor,* Bloomsbury, 2013

Horn-van Nispen, M.L. ten, and Ravesteijn, W. *Road to an Empire*, The Journal of Transport History, pp 40-57, 2009.

Hungspreug, S. Khao-uppatum, W. and Thanopanuwat, S. *Flood management in Chao Praya River Basin*, The Chao Phraya Delta: Historical Development, Dynamics and Challenges of Thailand' Rice Bowl, pp 1-20, 1999.

Ishii, Y. *Thailand: A rice-growing society*, The University Press of Hawaiii, (Original publication in Japanese in 1975), 1978.

Keshinen, M. *The Lake with Floating Villages: Socio-Economic Analysis of the Tonle Sap Lake,* International Journal of Water Resources Development, Volume 22, Number 3, pp 463-480, 2006.

Keshinen, M. Kkonen, M. Tola, P and Varis, O. *The Tonle Sap Lake, Cambodia, water-related conflicts with abundance of water*, The Economics of Peace and Security Journal, Volume 2, Number 2, pp 49-59, 2007.

Miksic, J.N. and Goh, G.Y. *Ancient Southeast Asia*, Routledge World Archaeology, 2017.

Morita, A. *Multispecies Infrastructure: Infrastructural Inversion and Involutionary Entanglements in the Chao Praya Delta*, Thailand, ETHNOS, Volume 82, Number 4, pp 738-757, 2017.

Mekong River Commission (MRC), *Impacts on the Tonle Sap Ecosystem, Assessment of Basin-wide Development Scenarios*, Basin Development Plan Programmme, Phase 2 (Number Technical Note 10), Mekong River Commission, Vientiane, Lao PDR, 2010.

Nara, P. Mao, G.G. and Yen, T.B. *Climate Change Impacts on Agricultural products in Thailand: A Case Study of Thai Rice at the Chao Praya River Basin*, 2013 4th International Conference on Agriculture and Animal Science/ 2013 3rd International Conference on Asia Agriculture and Animal, pp 136-140, 2014.

Nesbitt, H.J. *Rice Production in Cambodia*, Cambodia-IRRI-Australia Project, International Rice Research Institute, 1997.

Nguyen, Y.T.B , Kamoshita, A. Araki, Y. & Ouk, M. *Water availability, management practices and grain yield for deepwater rice in Northwest Cambodia*, Field Crops Research, Volume 152, pp 44-56, 2013.

Norlund, I. Cederroth, S. Gerdin, I. *Rice Societies – Asian Problems and Prospects*, Studies on Asia Topics, Number 10, Curzon Press, 1986.

Perkins, D.H. Radeet, S. and Lindauer, D.L. *Economics of Development*, W.W. Norton & Company, 6th edition, 2006.

Phungpracha, E. Kansuntisukmongkon, K. and Panya, O. *Traditional ecological knowledge in Thailand: Mechanisms and contributions to food security*, Kasetsart Journal of Social Sciences, Volume 37, pp 82-87, 2016.

Pittock, J. and Nguyen K.V. *Floating rice in Vietnam, Cambodia and Myanmar*, The Australian University, pp 2-28, 2016.

Pluvier, J.M. *Historical Atlas of South East Asia*, Brill, New York, maps numbers; 5,6,19 and 44, 1995.

Potter, R.B. Binnes, T. Elliot, J.A. and Smith, D. *Geographies of Development*, Pearson Education Limited, 2dn edition, 2004.

Poulton, P.L. Dalgliesh, N.P. Vang, S. and Roth, C.H. *Resilience of Cambodian lowland rice farming systems to future climate uncertainty*, Field Crops Research, Volume 198, pp 160-170, 2016.

Ravesteijn, W. *De Zegenrijke Heeren der Wateren*, Delft University Press, 1997.

Ravesteijn, W. and Kop, J. (editors), *For Profit and Prosperity, The contribution made by Dutch Engineers to Public Works in Indonesia 1880-2000*, KITLV Press Leiden, 2008.

Reid, A. *A History of Southeast Asia: Critical Crossroads*, John Wiley & Sons Incorporated, 2015.

Reid, A. *Inside Out: The colonial displacement of Sumatra's population,* in P. Boomgaard, F. Colombijn and D. Henley, *Paper Landscapes; Explorations in the Environmental History of Indonesia,* KITLV Press, pp 61 -90, 1997.

Sjoberg, O. and Sjoholm, F. *The Cambodian economy: ready for take-off?* The Pacific Review, Volume 19, No. 4, pp 495-517, 2006.

Sophonpanich, W.S. *Flooding in Thailand: flee, fight or float,* Forced Migration Review, No. 41, pp. 16-17, 2012.

Van Liere, W.J. *Traditional water management in the lower Mekong basin*, World Archaeology, Volume 11, No. 3, pp 265-280, 1980.

Wheatley, H. *Agriculture, Resource Exploitation and Environmental Change*, An Expanding World, Volume 17, 1997.

Wittfogel, K.A. *Oriental Despotism: A Comparative Study of Total Power,* New Haven: Yale University Press, 1957.

Links:

Map of Koppen climate zones: https://www.researchgate.net/figure/Map-of-the-Koeppen-Geiger-climate-classification-used-in-this-study-TRO-W-tropical-wet_fig1_322212659 (accessed 27-07-2018)

Article on the Mekong Mainstream Dams, International Rivers Organization, https://www.internationalrivers.org/campaigns/mekong-mainstream-dams (accessed 14-10-2018)