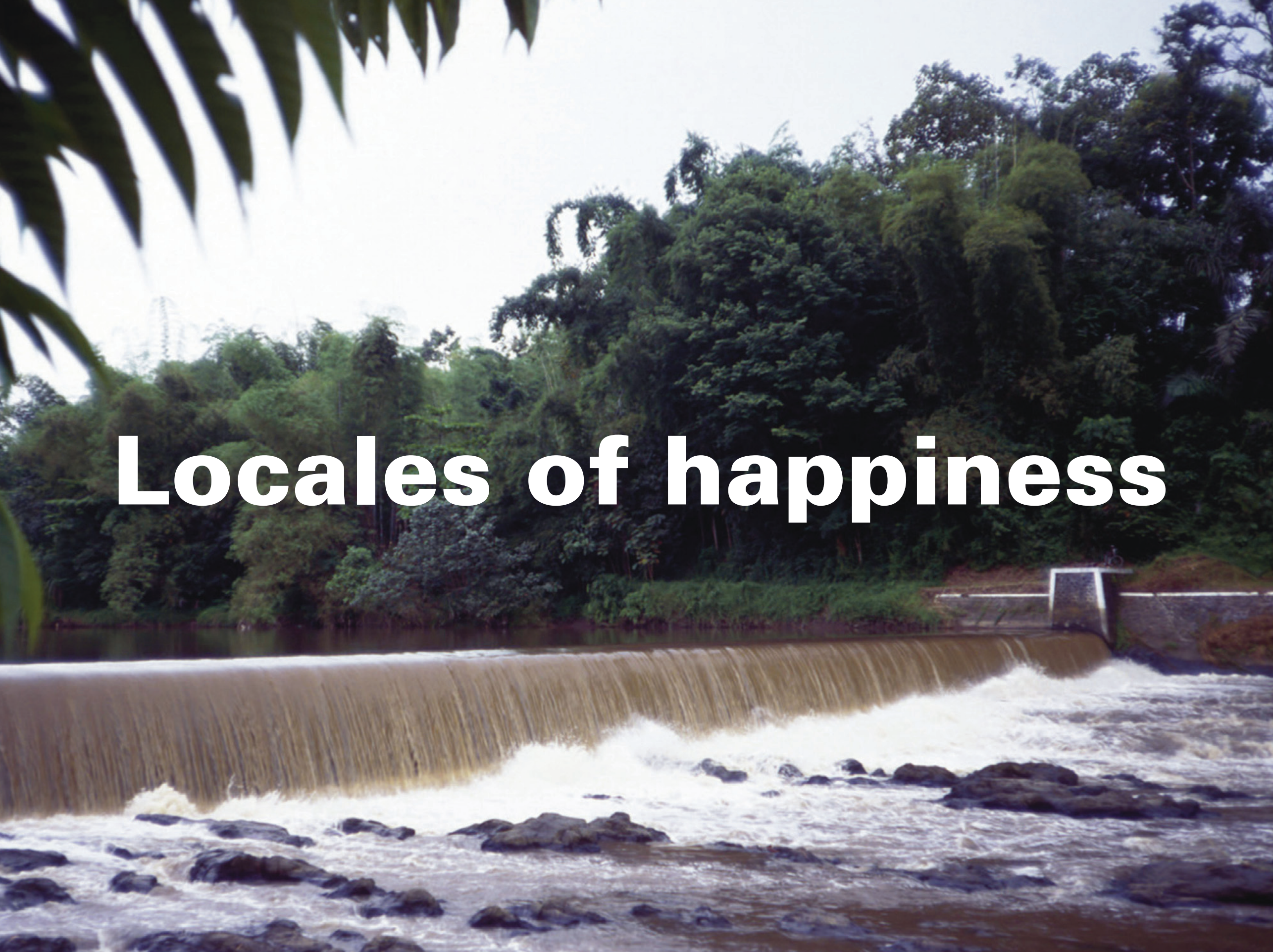

Locales of happiness

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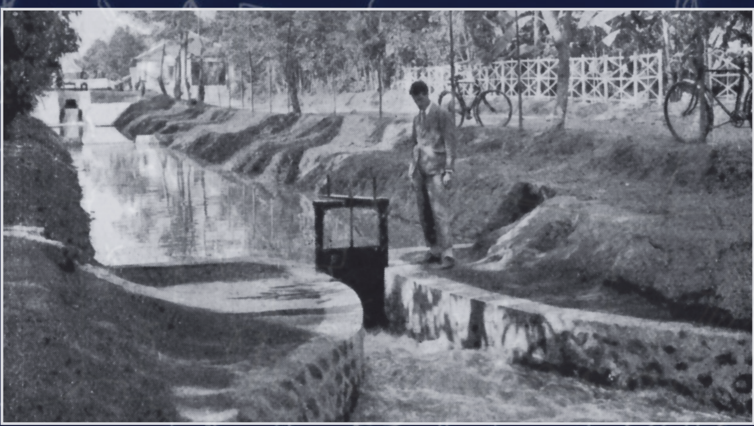

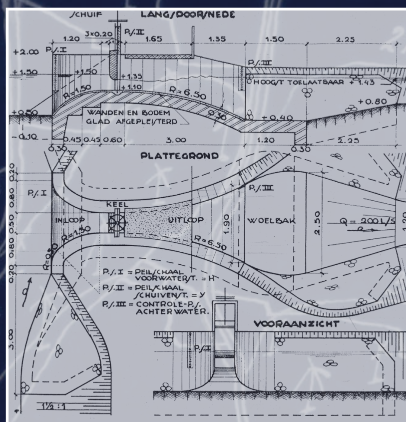

Maurits Ertsen

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Preface

I have not been really good at writing prefaces. Perhaps thanking people is not my thing, but I do like to think that is not the case. I may just not see the need to thank people who know they helped me on the first page other people will read in any book (that is, after checking the references to see whether they are in…). But I was persuaded to write a preface for this book, so here it is. First, I would like to apologize to Paul Josephson, for using the I-word throughout this book. Sorry Paul, your advice on this matter came too late. And I may disagree as well. Second, I would like to thank the many people that helped me to do the work leading to this book, particularly the colleagues from Indonesia and the very helpful staff of the Dutch National Archives. Third, I apologize for the mistakes in the book. I have tried to assure the book is free from mistakes, but I know I failed. Hopefully, the book is still interesting to many. Finally, and this may be the subject I tend to be bad at expressing, but consider it as the main reason to write a preface in the first place, allow me to assure you that publishing a book is fun, but that having the greatest children of all and being with the cutest woman on the planet is much, much more satisfying…

Maurits
Delft, April 2010

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1 Tracing back a river

Introduction

In 1993 I graduated as an irrigation engineer at Wageningen University. I must confess that I did not really consider that as strange. Obviously, as anyone, I did know that the Netherlands' international reputation is one of water excess, or drainage, not of water needs, or irrigation. Furthermore, with an MSc thesis on irrigation in the Netherlands East Indies, I knew that Dutch irrigation efforts on Java were substantial. It was not until I started working at Delft University of Technology, however, that I realized that at least two questions needed explanation. The first issue, why one could graduate in irrigation in a drainage country, seemed rather straightforward. One could still graduate in irrigation engineering in the late 20th century in the Netherlands, in Delft or Wageningen, because the Netherlands promoted its water knowledge within the international arena of development cooperation. Irrigation projects were vital elements within development policies. A second issue popped up, however, when I started looking at irrigation education in Delft. Within the lecture notes, I encountered many elements apparently taken directly from examples from the Netherlands East Indies. Specific discharge measurement structures were to be applied, and canal capacities were to be calculated according to a certain procedure. How could I explain the survival of these Dutch colonial elements within the general discipline of irrigation? This apparent persistency of colonial irrigation elements in Dutch irrigation practice and education is the main source of inspiration for this book; the Netherlands East Indian irrigation regime, consisting of explicit and implicit rules for irrigation design is its subject. Many studies discussing irrigation development in the Netherlands East Indian colony exist[1]. A study trying to understand the technical development process of irrigation seems to be missing; this book claims to fill (part of) this gap. I intend to explain two related issues: (1) how did the Netherlands East Indian irrigation school develop and (2) what happened with this school after Indonesian independence?

Persistency

Accounts of persistency of colonial irrigation practice have been made by several authors. Colonial British irrigation design and water management concepts still shape to a large extent daily irrigation practices and discourses in Pakistan and India[2]. Different 'schools' of irrigation development, similar to the British example, emerged in the context of colonies, as the Dutch did in the Netherlands East Indies and the French in north-western Africa. The American school may be the only one without colonial connotation, although elements of Spanish influence can be detected[3]. An irrigation school is a tradition of practice, comprising information physically embodied in a community of practitioners and in rules for action which these practitioners master. Traditions define accepted technical operations and encompass aspects of relevant scientific theory, engineering design formulae, accepted procedures, specialized instrumentation, and usually some kind of ideological rationale[4]. An important mechanism in this process of preference-guided selection of design solutions is engineering education; graduating from engineering programs is like passing the preparatory demands for community membership.

In the 1960s and 1970s, irrigation engineers developed irrigation schemes applying the well-known design practices of their respective schools, which were treated as 'the best possible method'[5]. Nowadays, modern irrigation science appears to the observer as an international, homogeneous body of knowledge. There seem to be no different schools of thought; one could speak of the modern paradigm of irrigation promoted by the World Bank, the International Commission on Irrigation and Drainage and other international organizations. Perhaps this international paradigm is dominated by American irrigation science. However, when looking closer, a somewhat more complex picture showing different approaches to irrigation and its problems replaces the picture of uniformity. Within irrigation modernization discussions French-based downstream controlled demand management and American-based upstream controlled arranged management approaches seem to be contrasted[6].

With an obvious restriction in the empirical material being limited to Dutch irrigation, even such a limited focus should allow me to contribute to a continuous debate within the community of those who engage with the history of technology[7]. Traditionally, studies on histories of technologies focused on the bolts and nuts of technologies and its great inventors, with hardly clear and systematic exploration and explanation of the societal context. Brave men and their machines was the discourse. As a response, particularly in the last three decades, studies of technological systems, social construction of technology and the influence of class and gender have enriched the field of history. There is not much sense in denying that in many of the earlier studies the relation between technical development and society has been represented quite one-sided in terms of discoveries, inventions and successful applications of individuals who brought their discovery from its isolated niche in the open for society to prosper. On the other hand, though, new approaches focusing on understanding technical development as determined by societal forces allow society to determine shape and selection of technology, but technology hardly overcomes a status of passive artifact. Furthermore, daily activities of those engaging in developing technologies, our former heroes, are usually left out.

Technological regimes

When this well-known discourse between internal and contextual approaches is presented, the author usually claims that he has overcome the differences. Indeed, my claim is not very original, but I intend to do credit to both approaches in my analysis of Dutch colonial irrigation. I discuss technical development as a process influenced by societal forces as well as by successful discoveries or applications by individuals. The concept of technological regime I apply aims to link the two positions[8]. The regime concept is based on the recognition that

> 'invention and innovation are conditioned by such factors as earlier innovations, the search heuristics of engineers in an industry, available technical knowledge, market demand and industrial structure.' [9]

The regime concept bridges another gap as well, as

> '[b]etween the formalized knowledge that can be traced through courses and treatises, and the everyday decisions made by engineers, there must be for sure some kind of intermediate know-how.' [10]

This intermediate know-how, transformed in rules structuring the how and what to do, shapes a technological regime. Engineering education, transferring existing knowledge and design rules to new engineers who have no direct link with the practice in which the rules were developed, can be considered as a structuring element. Another such a structuring element closely related to education materializes in engineering handbooks. Successful approaches become examples, even blueprints for technological design. Selected examples are presented to students at engineering schools. The professional engineering organizations, including educational institutions, but also Departments of Irrigation (or generally Public Works), select, discuss and promote successful technological solutions. Gradually, a technological regime develops[11].

Technological regime development is a two way process between structures and actors. I define a technological regime as a set of rules structuring activities of actors involved in development and use of a certain technology[12]. Rules can vary in form and content; some are related to design of technologies, others to use, others to divisions of labor.

> 'Some rules will be explicitly laid down in requirements and technical norms. Other rules will be tacit and implicit and will be followed by the actors on the basis of habits or tacit knowledge. […] Rules in technological regimes can also be embodied in production apparatus or technological artefacts.' [13]

The totality of relevant rules shapes the technological regime. Within a technological regime different categories of rules can be ordered hierarchically; I employ five of these categories[14]. Together these five categories shape the irrigation regime (Figure 1.1). Basic founding premises are (1) 'guiding principles', which relate the design of a technology to doctrines and values used to legitimize a tradition and its outcomes. Closely related to these principles are the (2) 'promises and expectations' about a future technology, which will be translated into more specific requirements for new technologies. I employ the term (3) 'design requirements' to describe functions to be fulfilled by an artifact and boundary conditions that are important in the design of a technology. To enable the fulfillment of requirements, (4) 'design tools' are employed, including scientific knowledge, design heuristics, technical models and formulas, design methods and approaches. Category (5) 'artifacts and operation' includes the result of any design activity; both in the meaning of physical objects as in the meaning of operation and management procedures. Artifacts may not be considered as rules, as they only fulfill functions and have to meet design criteria and requirements. On the other hand, artifacts can and certainly do function as exemplars: future designers still apply them because they are known or have been proven in practice.

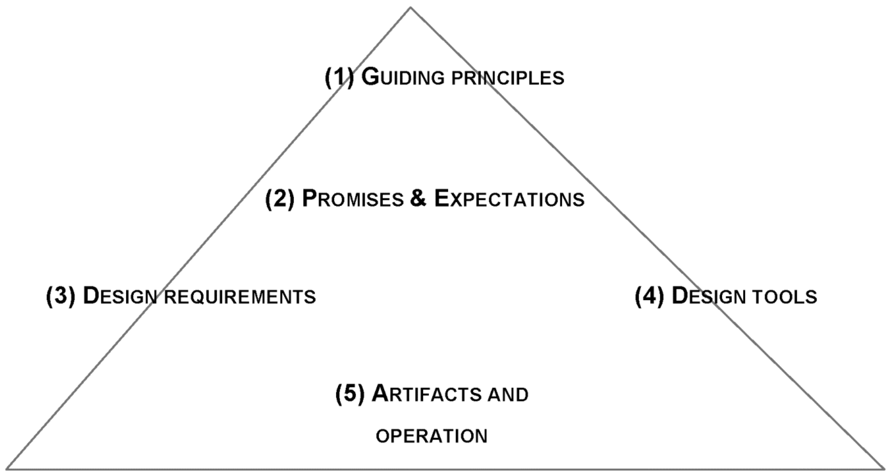

Figure 1.1 The technological regime triangle [15]

The categories are structured in a hierarchy; guiding principles are on a higher level than design tools. In the Netherlands East Indian context, higher level not only refers to the more abstract nature of guiding principles in contrast to for example design tools, but also to the larger number of stakeholders involved in and the political connotation of formulating guiding principles. As we will encounter in this book, debates on the appropriate foundations for colonial water policy involved civil servants and engineers, government and private industry. On the other hand, discussions which discharge measurement structure to be used to realize this water policy were exclusively situated within the civil engineering circle. Higher level rules structured the development process of lower level rules like design tools and artifacts.

Even though drawing boundaries exactly of a technological regime beforehand might not be needed[16], one could define regimes rather broad or rather narrow. I tend to start from a relatively narrow definition, perhaps even a rather traditional position, analyzing the development process of Netherlands East Indian irrigation focusing on the rules that structure activities of actors involved in its development. To narrow down my approach even further: I am mainly interested in the actions, discussions and positions of Dutch irrigation engineers in shaping their irrigation design approach. Some authors would regard this as a rather restricted interpretation of the concept of technological regime, but I will show that such a restricted regime concept has strong explanatory power to understand the development process of Dutch irrigation. I would even like to claim that my restricted concept has more explanatory power than a broader conceptualization, as restriction allows pointing out key elements of the regime and explaining preferences and actions of the main actors involved much better.

Structuration

The extremely simplified description of regime development given above has some apparently functionalistic connotations: rules on one level shape rules on lower levels. Such a description obviously will not do at all for a better understanding of technological regimes. Functionalism is the last thing I want to defend; humans, not abstract forces, created the irrigation works and knowledge in the Netherlands East-Indies. I am much more interested in conceptualizing technological traditions in the way Giddens discusses the concept of structure[17].

> ‘'Structure' refers to 'structural property', or more exactly, to 'structuring property', structuring properties providing the 'binding' of time and space in social systems. […] [t]hese properties can be understood as rules and resources, recursively implicated in the reproduction of social systems.’ [18]

Structures do not exist; they manifest themselves through the constituting moments of social systems. This

> ‘[…] implies recognising the existence of: (a) knowledge – as memory traces – of 'how things are to be done' (said, written), on the part of social actors; (b) social practices organised through the recursive mobilisation of that knowledge; (c) capabilities that the production of those practices presupposes.’ [19]

Regime development is a social activity; in social interaction human actors construct technological regimes as they construct society.

> ‘Human social activities, like some self-reproducing items in nature, are recursive. That is to say, they are not brought into being by social actors but continually recreated by them via the very means whereby they express themselves as actors. In and through their activities agents reproduce the conditions that make these activities possible.’ [20]

Generally, in daily practice we reproduce existing, historically grown sets of rules by applying and changing them. To know a rule is to implicitly know what one is supposed to do in particular situations and rules are widely used and sanctioned. Although they show a tendency to be stable, rules are not static[21]. Rules do not develop by themselves, nor are they followed simply because they are there. Actors, real people, make and break rules. Actors will follow the relevant rules, or in my case act within the technological regime, not just unconsciously or routinely, but also because they think they have something to lose by not acting in accordance with the rules, or something to win if they do[22]. Human activities are recursive. Structures, regimes or rule sets, do not exist as patterns in time and space by themselves, but only become concrete through human action; society is reproduced through human action. What remains somewhat unclear from the discussion above is where the action actually is. In this book, the social construction process of the irrigation regime is located in the East Indian colony between 1830 and 1940, and after World War II in independent Indonesia and the Netherlands.

This book

Stressing continuity[23] in the social construction process of the Dutch irrigation regime does not imply that the regime developed like some external force, with a will of its own, without any possibility for actors, either engineers, farmers, civil servants or any other, to influence its course. Fierce debates took place in the colony and the Netherlands, in particular on the issue of water allocation, regulation and distribution. Different social groups disputed over policies to develop, about the rules for irrigation development. Actual outcomes of this confrontation between social groups have been influenced by changes in colonial political, economic and institutional settings. I intend to show throughout this book, that the basic guiding principles of Dutch colonial irrigation and its related design practice were set relatively early, that is before the First World War, and have not been transformed afterwards, despite continuing debates. Furthermore, I will defend the position that irrigation engineers were the dominant group to determine requirements, shape and format of colonial irrigation systems and consequently of most of the colonial irrigation regime.

In Chapter two, I discuss guiding principles and promises/expectations for colonial irrigation development processes in British India, British and French Africa and the Netherlands East Indies. Irrigation development in colonies did not only have to serve the colonial powers, but also the colony itself; it would not serve mere exploitation, but also become an element of a policy of productive imperialism. I take the analysis to a more detailed level in Chapters three and four, when I discuss the process in which guiding principles, design requirements and artifacts in the Netherlands East Indies developed. The agrarian policy of the Dutch colonial powers is vital in explaining why a Netherlands East Indian approach could develop. The most important founding element in Dutch colonial irrigation, or guiding principle, was the mutual presence of food and commercial crops, respectively rice grown by peasants and sugar cane by the industry, in the same irrigated area. Consequently, the need for adjustable water control was defined as a design requirement; to realize such control two types of artifacts were needed: management regulations and structures.

In Chapters five and six, I discuss the design of the West-Javanese Tjipoenegara irrigation system. The period in which this system was designed and built, roughly between 1920 and 1935, is a key period for two reasons: from a theoretical point of view a closer analysis of the timeframe sheds light on the question of regime construction and continuity; from design point of view this timeframe brought a series of new elements. Most design decisions appear to have been the responsibility of engineers; most of them relate to the regime categories of design requirements, tools and artifacts. An important design rule appears to be anticipation on the presence of sugar cane next to rice in the irrigated area, requiring control over flows varying in time and space in the irrigated area. Within this guiding principle, the engineers constructed their design approach.

In Chapters seven and eight I discuss irrigation planning and engineering after World War II, when Indonesia became an independent republic. The case study of the Lampung area, Southern Sumatra, shows that irrigation activities in Indonesia were influenced by design rules developed by Dutch engineers in colonial times, even when representatives of other irrigation regimes were involved. Although Dutch irrigation engineers started working in other regions, irrigation education at Delft Polytechnic did not reflect such interest for a long time. Delft irrigation education remained based on the colonial technological regime up to the 1980s. In the conclusions, I will distinguish between two phases in the development process of the Netherlands East Indian irrigation regime. Between 1870 and 1910 the guiding principles, promises/expectations and the majority of the design requirements took shape. The focus in this phase was on developing prescriptions for irrigation design. The phase between 1910 and 1940 was an elaboration phase, in which tools and artifacts to translate general rules into infrastructure were defined. Focus was on perfecting tools and artifacts applied in irrigation design.

2 A juggling act

Exploring colonial irrigation development

Irrigation was an important field for most major European colonial powers. Irrigation systems were, and are for that matter, constructed to achieve certain goals; irrigation was the material translation of colonial agrarian principles. Irrigation was perceived as a very good instrument to assure both economic development and food production; many colonial irrigation efforts were aimed at combining profitable cash crops with food production. For the two most important colonial irrigation projects in Africa, at least in terms of command area, the British Gezira Scheme in Sudan and the French Office du Niger Scheme in Mali, the potential to grow cotton for the European market was an important stimulus to start the systems, but the ability to grow food crops (grains) was also considered. Whatever crop selected, economic development should not only serve the colonial powers, but also the colony itself; it should not only be mere exploitation, but also become an element of a policy of productive imperialism.

In this chapter, we take a colonial irrigation tour from British India to the Netherlands East Indies to end with British and French irrigation activities in Africa, including Egypt, the British Sudan (1880–1950), the French Sudan (1830–1960) and French Northern Africa (1830–1965). For many colonial powers, British India set the standard for a successful colony. One could fill many libraries with documents produced on efforts and results of India, and irrigation is not neglected in these documents. British policies and projects to develop irrigation were driven by two issues, which continuously had to be balanced[1]: (1) irrigation could be an immensely profitable undertaking creating wealth, prosperity, productivity and political-economic stability; and (2) it was a precarious undertaking that required continuous fine-tuning of technical and managerial issues in order to create and maintain conditions for such profitability. I will show that these two issues were also important in other colonial areas. The answers colonial powers defined, however, differed per colony. As a result, guiding principles and promises/expectations differed between India, the Indies, the Sudan, the Niger Delta and Northern Africa.

Britsh India

British canal-building activity in India started in 1817 and concentrated largely on the plains to the north of Delhi and the deltaic regions of Madras, South India.[2] Annexing the Punjab in 1849 meant that the British gained control over the Indo-Gangetic plain. They lost little time in starting the construction of several canal systems. There were several reasons; improvement of the revenue-producing capacity of the lands they annexed was one, another was fear of famine. However, a most important objective was to provide employment for Sikh Army veterans, from the army disbanded in 1849.[3] A focus on easy returns reinforced the already existing focus in canal irrigation development on the alluvial plains of the North and the deltas of the South.[4] In these areas system construction was relatively cheap. However, some of the most drought and famine prone areas were located in interior areas of India, particularly in the Deccan region, where many rivers were not perennial or had very low base flows. Irrigation systems in this region were more expensive to build and therefore less remunerative. Some of the most drought and famine prone areas were not provided with irrigation facilities.[5]

The new irrigation efforts took place in a relative knowledge-vacuum.

> 'The builders of canals needed [...] to devise economical ways of tapping the great rivers, with their tendency to wander and their variable flow over the year, and to convey that supply to and along the watersheds of the tract via a network of canals and distributaries, taking care to avoid interruption to the complex and often subtle drainage lines. They had also to avoid the danger of damage to the works posed by the boulders carried by the flow of the rivers emerging from the hills, the serious scouring effect of water travelling at excess velocity in unlined alluvial soil channels, and the problem of the channels filling with silt where the flow speed was inadequate to keep the material suspended in the water.' [6]

Most of these problems were new and could not easily be tackled with existing experience on (smaller) irrigation works in Europe. In terms of irrigation systems and water management, the early British systems

> 'were no more than sophisticated man-made river diversions, rather than controlled water distribution systems [...]' [7]

Command areas were large, with canals up to several hundreds of kilometers; control structures were lacking and available management capacity was low. British attention focused on constructing the main canal system, and water users had to construct the canals to bring water to the fields. In most cases, the connection between the main and field systems

> 'consisted of nothing more than a simple open-cut, there was virtually no control on water being taken by each farmer or village channel.' [8]

Notwithstanding the difficulties the uncontrolled systems posed to the design engineers, from a policy perspective it was much more important whether land could be irrigated than how it was irrigated. A major governmental interest to develop irrigation was the possibility to increase land revenues from irrigable areas. Land taxes were based on the possibility to irrigate the land, not on production increases resulting from irrigation. The British provided Indian agriculture with water, but what India did with it was India's own case, as long as it paid revenues. Such approach fits with the policy of indirect rule in India. The British tried to preserve the existing social structure as much as possible, using existing institutions and only replacing the top layers with British servants.[9]

The British focus on revenues through taxation of land posed a dilemma:

> '[…] how to derive as much revenue as possible, without causing pauperisation, famine and/or revolt?' [10]

The British choice for indirect rule, leaning on local, traditional rules and rights potentially could contradict another aim of the colonial authorities. The British, as most colonial powers, stressed their role as modernizer of the colony, in order to promote and impose a

> "fair and equitable' political-economic system' [11]

Developing irrigation was a key element in modernization, especially as the results of the first irrigation projects were highly satisfying: they prevented famines and gave handsome returns even in rainy years.[12] In summary, the objectives, or guiding principles of the British colonial involvement in irrigation were already developing in these early decades of irrigation efforts[13]:

1. To increase the collection of land revenue
2. To provide a means of famine protection
3. To maintain political and social stability

British colonial irrigation design

One of the first British colonial irrigation systems was the Ganges Canal, opened in 1854, constructed as a response to a severe famine in 1837-38[14]. Construction of the canal started in 1843 and the canal became fully operational in 1857. The Ganges Canal is associated with engineer Cautley[15], who referred to the northern plains of India as

> '[…] designed by nature as a great field of artificial irrigation' [16]

The way Cautley became involved in irrigation appears to be typical for British irrigation involvement in the early decades of the 19th century. Cautley's education was minimal; he had received one year's training as an artillery cadet before being sent to India in 1819.[17] During a three-year home leave in Britain, he studied the Caledonian Canal, built from 1803 to 1822. On his way back to India in 1848, he stopped off in

Italy and Egypt, to study what was considered the most advanced irrigation then to be found.[18] At that time, little was known about flowing water in large earthen channels. One of Cautley's major problems was to calculate the correct slope of the Ganges Canal, to avoid both scouring and silting. Using the formulas devised by two French hydraulic engineers, Dubuat and Prouy, and experiences from the Doab and Delhi Canals, he designed an incline of 24 centimeters per kilometer in order to obtain a water velocity of 1.08 to 1.23 meters per second.[19] After the inauguration of the Ganges Canal, a serious defect became apparent: the water flowed too fast.[20] The main errors were corrected during the late 1860s. The remodeling consisted of adding protective works to the fourteen masonry falls and raising the crests to reduce the slope of the canal.[21]

After the Mutiny (1857-58), the Crown took over the rule of India from the East India Company. As a result, a change in modernization policy occurred, with technology, especially irrigation and railways becoming the main tool of modernization.[22] Between 1858 and 1866, the government experimented with irrigation development through private irrigation companies, because the cost of irrigation construction, in terms of initial capital outlay, was beyond governmental means at that time. In 1866 the government decided that canal irrigation should again be a state activity.[23] State control implied also a reformulation of goals to be achieved by irrigation. From approximately 1860 onwards, irrigation schemes would fulfill many goals, including famine protection, revenue stability, the settling of unruly tribes, expansion of cultivation, extended cultivation of cash crops, enhanced taxable capacity, improved cultivation practices, and political stability.[24] In short, irrigation was an important instrument for almost all fields of governmental policy.

Not surprisingly, the Canal and Drainage Act of 1873 extended the responsibilities of the Irrigation Authorities, strengthening its control over the canal network, outlets (thus tertiary command areas) and rotation schedules.[25] However,

> '[…] the fundamental duality in colonial policy was reproduced in irrigation policy: increase revenues and promote cash cropping, and simultaneously maintain stability and ensure continuation of British rule, threatened by famines and social unrest.' [26]

Discussions were stimulated by a concern over financial returns on irrigation.[27] The major administrative problem of irrigation remained its financing. Projects were expensive, took decades to be completed and required long-term financing.[28] Perhaps the government should diminish its public works program. As the railway lobby was particularly powerful, irrigation financing was cut back sharply in 1875, while expenditure on railways rose.[29]

Productive and protective irrigation

In 1879, a Parliamentary Select Committee, the Indian Famine Commission was established to examine how loan capital raised in London for Indian irrigation works might be safeguarded.[30] In financial terms, the early irrigation schemes mainly aimed at maximum returns on minimum investments, which was generally very remunerative. These irrigation systems were called ‘productive’ systems. Extending the goals of irrigation by the state made less financially remunerative systems an option, so-called ‘protective’ works.[31]

> ‘This change in policy was formalised after the report of the Indian Famine Commission 1878-80, which drew attention to the indirect returns related to irrigation in terms of protection against famine. […] In protective schemes irrigation water was supposed to be supplementary, enough to save the traditional food crop during a drought. Protective works were not required to pay back interest on capital expenditure, but were primarily aimed at famine protection.’ [32]

The Committee had to examine the history of famines as well and to assess the value of famine relief and protection measures.[33] In its report, the Committee concluded that irrigation actually yielded a small profit. Financing the construction of irrigation schemes with loans could be continued[34], but new schemes had to pass the productivity test of 1879, which had been designed by the Committee. The test distinguished between protective and productive schemes.

> ‘A profitability criterion expressed as the percentage return over total capital outlay was fixed (varying over years) which was the cut-off point for approving new projects. Projects with direct financial returns lower than that percentage were rejected. Schemes approved were called ‘productive irrigation’ schemes. The Famine Commission recommended to construct schemes with lower returns as well, with the aim to prevent famines and thus depress famine relief costs.’ [35]

An area was considered protected when 42.5 percent of it could be supplied with water; either from wells or canals.[36] A designation as productive work did not mean that the scheme would not have a role in combating famine.[37] Adding a category of protective schemes, however, broadened options, as it enabled the government to continue with irrigation schemes, which were not remunerative. To finance the schemes, the Famine Fund was created.[38]

Although protective works had been made possible, the investment criterion from the productivity test actually preserved the focus on the North(west) and the deltas of the South, as irrigation development in these areas was cheaper and thus more remunerative.[39] The area irrigated by productive works increased from 1.9 million ha in 1878 to 4.4 million ha in 1900.[40] The area covered by protective irrigation covered 0.14 million hectare by 1900[41]; in 1902-03 a total of 0.37 million acres was counted[42]. Some new famines increased the popularity of protective irrigation. The Indian Irrigation Commission (1901-1903) reported how irrigation could be used as a protection against famine.[43] The Commission report gave a stimulus for increasing protective irrigation areas, although the gradual exhaustion of suitable sites for productive schemes may have helped too... The Commission suggested that investments of up to three times the projected savings in famine relief costs might be considered, thus extending the scope of protectivity.[44]

Over time, protective irrigation received three different meanings, although overlapping, in chronological order. The term was used to indicate the protection against famine by irrigation (before the Famine Commission), as a financial-administrative class of works in colonial irrigation policy (based on the productivity test of the Famine Commission), and as a specific type of irrigation (during the 20th century, especially after the first decades).[45] Generally speaking, protective irrigation systems were designed and operated on the principle that the available water in rivers or reservoirs has to be spread thinly over a large area, in an equitable manner.[46]

By 1921, 57 million pounds had been spent on productive works for 17.3 million acres and 12 million pounds on protective works for ¾ million acres in India; the net revenue was about 9% and 1% respectively, with a combined net annual profit of 3.1 million pounds.[47] Even with increased attention, in 1947 just 16% of the total area of colonial canal irrigation accounted for protective systems. Most protective schemes constructed after 1900 were located in the Bombay and Madras regions.[48] These protective schemes had serious competition from colonial irrigation development in the Indus-basin,

> 'where huge tracks of crown-waste land could be converted into the granaries of the Raj, by means of the so-called 'colony irrigation systems', that yielded impressive levels of remuneration of up to 45 percent.' [49]

Modern India has about 12 million hectares of protective irrigation, about 40% of total canal irrigation; modern Pakistan has about 12.5 million hectares of protective irrigation schemes, roughly 85% of large scale canal irrigation in that country.[50] The rationing of water in Northwest India and Pakistan is controlled under the so-called 'warabandi' system of water distribution, in which water is allocated to landowners or plots for a fixed time period proportional to the size of the landholding.[51] The rationing of scarce water in the Southern systems is controlled by 'localization', prescribing which crops are to be grown on what plot in which season.[52] In Maharashtra and Gujarat farmers request water before the season to the Irrigation Department. These demands are sanctioned by the Department and distributing of water is rotational.[53]

British-Indian irrigation will return in Chapter four, when the relation between water management goals and irrigation infrastructure is discussed further. For this moment, the main message is that irrigation systems in British India were aimed at maximizing economic profit through an increased land tax from irrigated land in contrast to dry land. In addition, after 1860 and in response to severe famines, the British introduced the concept of protective irrigation: schemes were designed to provide small amounts of water to large numbers of acres; these small amounts should be enough to save food crops during drought. Productive or protective, British irrigation approaches employed the principle that 'water follows irrigated surface'. This coincided with the British indirect colonial rule, which depended on land exploitation through a land revenue system; land that could be irrigated was taxed higher than un-irrigated land; actual harvests were not taken into account.

Dutch colonial irrigation on Java

When the Dutch arrived on Java they found people who were making a living from farming, either rain fed or irrigated. Irrigation technology has been an important factor in the expansion of wet rice farming in the Indonesian archipelago from early times.[54] In the beginning the Dutch were impressed with Indonesian irrigation technologies and results, but this soon changed. Especially the engineers stressed that indigenous irrigation structures were unsatisfactory. Of course, it was in their interest to do so too, given their relatively weak position within the early colonial state; developing engineering irrigation was important to strengthen the position of engineers within the colonial bureaucracy. Early colonial engineers were raised in the Dutch water tradition; they were experienced in the struggle against water. Next to confronting the engineers with severe drainage and flooding problems, however, Java demanded a struggle for water quite different from the mother country; in this respect the engineers had to start pretty much from scratch. Until about 1885 the Dutch usually designed the main structures, like weirs in rivers and feeder canals, and connected them to existing Javanese irrigation systems. Afterwards, the approach focused on comprehensive irrigation schemes, based upon the experiences of the earlier period.

Dutch colonial irrigation activities started on behalf of the European sugar cane cultivators in the 19th century, but later efforts were also directed at supporting and improving the rice-cultivation methods of the indigenous population. An early issue was irrigation revenue. Within the so-called Cultivation System ('Cultuurstelsel'), introduced by Governor General Van den Bosch in an attempt to make a profit from the colony after the Java war (1825–1830), Javanese farmers had to cultivate certain cash crops. When in the second half of the 19th century the Cultivation System was gradually replaced by a policy of free trade and production, the colony still had to deliver a profit for the mother country. Irrigation development was seen as one of the areas for the colonial government to endorse profitable economic production as well as food security. The commercial crops were grown in the same areas and fields as used for rice; the commercial agricultural enterprises did not own land as they would have done in a plantation system, but rented land from the Javanese farmers. From the first colonial irrigation efforts onwards the irrigation systems in the East Indies irrigated both sugar cane and peasant crops, rice in the wet West Monsoon between October and March/April and dry crops ('polowidjo') in the dry East Monsoon. Water had to be distributed to all these crops through the same canal system. Therefore, water distribution methods were designed to divide, distribute and measure the water between commercial and food crops in a just way. After discussions at the end of the 19th century on what 'just' actually meant and how it could be achieved, a centralized water management system developed, with engineers in charge[55]. The simultaneous presence of commercial and food crops within the same irrigation system shaped both colonial Dutch irrigation infrastructure and management.

Admiring the pioneers

In the beginning of the 20th century, when colonial irrigation engineers had established the foundations of a more systematic approach to irrigation design, many engineers admired their pioneering colleagues.

> 'Precipitate working, without preceding study of water levels and discharges, let alone of other hydrographically important circumstances, virtually became the rule. Therefore, works […], designed with gross underestimation of flash flooding capabilities of the rivers, often flushed away. Others, constructed without knowledge of lower discharges, disappointed in their water delivery' [56]

Especially in the first half of the 19th century the 'permanent' engineering structures were destroyed or seriously damaged by 'bandjirs' (flash floods) as quickly as the indigenous 'temporal' structures. One of these early structures constructed by Dutch engineers was a weir in the Sampean River, on the eastern outskirts of Java, in 1832. This dam was replaced several times by others, which suffered heavily from flash floods too. In 1887 a more satisfactory solution was established, with a combination of weirs, sluices, river improvements and bypasses. Even then, the rapid floods of the Sampean river could damage the structures considerably, as in 1916.[57] The Dutch colonial engineers struggled with the hydrology of Java. Nearly all Javanese rivers show a flow pattern with large fluctuations within and over days and seasons. Knowledge of the behavior of Dutch rivers was not applicable on Java. Irregular abundant rainfall and very steep slopes in the Javanese catchments resulted in large flash floods. Discharge measurements were not available and required too much time anyway; the Dutch engineers needed a method to calculate the expected peak flood discharge. Extensive visits to other irrigation regions, including British India, Spain, Italy, and France, and mountainous areas like Austria, Germany, and Switzerland were made; documents from these countries were studied. Between 1890 and 1940, Dutch engineers studied the matter; in 1895 engineer Melchior proposed a methodology that was used throughout the colonial period, despite occasionally severe criticisms on its appropriateness[58].

The Bureau of Public Works

The establishment of the Bureau of Public Works in 1854 was a political recognition of the potential role of engineers and technical support in colonial irrigation development; a main task of the Bureau was constructing irrigation works on Java. The engineers remained subordinate to the Civil Service, however; the 'Resident' (administrative representative of the Civil Service on regional level) usually took the initiative for irrigation development. Civil servants did not always call for the help of engineers though. Furthermore, the Bureau had to cope with lack of financial means and personnel; even in cases civil servants required support the Bureau could not always provide it. An engineer who devoted his career to improve the position of the irrigation engineers within the colonial state was H. de Bruyn, director of the Bureau between 1861 – 1868 and 1874 – 1877. Although he certainly did manage to increase attention for irrigation expressed in the growing number of preparatory studies, the actual number of projects realized was low before the last decennium of the 19th century. The quality of the works realized did improve, however, which strengthened the position of engineers.

In 1885, the Bureau of Public Works became independent from the general Civil Service. The new Department of Public Works became the centre of irrigation activities. A so-called Irrigation Brigade had to study possibilities to provide all governmental lands with modern irrigation facilities. In 1890 the General Irrigation Plan for Java defined 19 irrigation projects to be developed; some other projects were included in 1907. Most of these projects were located in East or Central Java. The importance of preparatory research increased, and the new approach of the engineers reflected the idea that irrigation systems needed to be considered as a 'coherent organism'[59]. Research on rainfall, river flows, soils etcetera was to be used for the design of irrigation systems with both head works and a network of canals and drains. Just two years before the General Plan, the first Irrigation Divisions ('Irrigatie-afdelingen') had been established. These management units on the level of river basins were responsible for design, construction, exploitation and maintenance of irrigation. Daily management within irrigation systems was arranged through regulations defining procedures for the allocation and distribution of irrigation water to different crops and use(r)s. Generally speaking, water distribution to sugar cane was separated from distribution to rice.

The economic aspect of irrigation works, although considered important before, was emphasized in 1897 with the establishment of the Rentability Commission. This Commission had to study the costs and benefits of irrigation projects; the economic effects of irrigation development had to be quantified. The cost-benefit criterion increased in importance in the context of the Ethical Policy introduced in 1901[60]. New welfare measures had to improve the position of the Javanese, but although the focus on profit from the colony was softened somewhat, measures on the terrains of irrigation, emigration and education were to be checked from an economic point of view. Another influence of the welfare policies was a growing attention for Javanese agriculture. As a result, agricultural experts from the Department of Agriculture, which was established in 1905, entered the irrigation scene, amongst others through a representative in the Rentability Commission.

It is not all gold that shines …

Irrigation was important in the welfare approach. Not everything the irrigation engineers did, however, was successful. The plans in the Solo Valley proved to be a case in point. At the end of the 19th century some 720,000 people lived in this area, basically the lower Solo basin, on a surface of half of the Netherlands. The first irrigation plans for the Solo Valley dated from 1852, but things speeded up in the 1870s. Irrigation plans were developed in connection with plans to divert the river outflow away from the Surabaya area to prevent sedimentation. The plans included a canal to Surabaya for transportation and drinking water purposes. This canal could also bring irrigation to more than 200,000 bouw (one bouw equals 0.7 hectare). The entire system would consist of a main canal of 165 kilometers and 900 kilometers of smaller canals. At the end of the 19th century it became clear that the project costs were much higher than anticipated and the project was suspended in 1898. The Minister for Colonial Affairs appointed a committee to study the Solo plans. The committee advised continuing the irrigation part of the plan.[61] On the technical feasibility the members of the Commission agreed unanimously; concerning the social-economic benefits of the Solo project, however, one of the members had strong doubts. In 1903, Minister for Colonial Affairs Idenburg decided to follow the minority advise to cancel the project altogether.

The abandonment of the Solo project caused much consternation among the Dutch engineers. It was perceived as a lack of confidence in engineering and seemed to set a temporary halt to larger-scale irrigation development. The General Irrigation Plan, however, was continued as planned. The irrigation engineers had successes to show too, with as main example of a successful irrigation system the Pemali system, with an irrigated area of about 45,000 bouw. As will become clear in this book, both the Pemali design process and water management regulation became the standard for irrigation in the East Indies. Developing water infrastructure was too important for colonial policies not to involve specialists who had proven their capabilities. In the early 1920s, when the first General Irrigation Plan was completed and colonial policies returned to normal after the First World War, a new set of irrigation projects was defined. The budget for irrigation reached its peak in this period with around ten million guilders per year. The number of engineers employed by the Department of Public Works passed 200 in the early 1920s and reached its maximum of 263 in 1930. Among these engineers, from whom the majority had graduated from Delft Polytechnic, were several who graduated from the new Polytechnic in Bandoeng.

Irrigation design procedures in the 1920s did not differ much from those applied in the 1890s, although formulas and artifacts had changed. Hydraulic laboratories in which designs could be tested brought a new dimension to design, although irrigation practice remained a determining factor within the engineering community. Both the economic recession of the late 1920s and the growing nationalistic sentiments on Java reinforced governmental attention for irrigation development, as it served food security and thus social stability. The political context changed somewhat, as irrigation works became the responsibility of the Provincial Public Works Departments. These provincial departments were the result of colonial decentralization policies; three provinces were established on Java, each with its own Public Works Department. In 1936 a General Water Regulation for Java was established; it was the first general water regulation in the colony, and the last … As a result of colonial irrigation policies, independent Indonesia counted 1.3 million hectares of land irrigated by engineering systems on Java in 1950; although considerable enough, this amount was less than half of the 3.3 million hectares of land in use for irrigated rice farming all together on Java in the same year.

British colonial irrigation in Africa

At the time that British and Dutch engineers were already at full speed in developing irrigation in Asia, colonial Africa was still relatively untouched by irrigation engineers. In November 1884, colonial powers like France, Great Britain and Germany settled their disputes over Africa territory at the Berlin conference in Germany. Egypt was an important subject on the agenda. The British occupation of Egypt in 1882 was not recognized by other European powers; nor was it in Berlin. Egypt remained, at least from legal point of view, part of the Turkish Empire. In March 1899, France finally had to give in after the Fashoda affair. In return, Britain recognized France's hegemony over the French Sudan. Through these political developments, the British assured that the cotton farms of Egypt, important for the British textile industry, were relatively certain that their water supply from the Nile would not be interfered with by other colonial powers. Within Britain's policy, controlling the water sources of the Nile and the territories the river passed through was highly important[62]. Thus, the Sudan, south of Egypt, became a subject of the strategy of the British Empire. Furthermore, Sudan formed an important link from the Cape to Cairo; it was essential in safeguarding the Suez Canal and the route to India. The Sudan had to be controlled by Britain and was conquered in 1898.[63]

The Gezira Irrigation System, British Sudan, 1900 – 1949

Shortly after the turn of the 20th century, in 1904 Sir William Garstin published a plan involving the entire Nile Basin – the first overall plan for the control of the waters of the Nile. Garstin's plan was the first to look beyond the needs of Egypt alone, but still directed the largest part of the waters of the Nile to Egypt. The position of Egypt remained one of the crucial issues to be negotiated, but the Sudanese British colonial power gradually succeeded in developing large-scale irrigation in their own territory.

Garstin had entered the Indian Public Works Department in 1872, and had been sent to Egypt in 1885. He suggested, among other things, increasing the storage capacity of the Aswan Dam, the first stage of which had barely been finished. Garstin proposed to use the Gezira plains as a wheat-producing area for the nearby Arabian market, with only a small emphasis on cotton; wheat would not need water in the scarce months. He proposed the building of a dam or barrage at Sennar on the Blue Nile to provide irrigation for part of the Gezira. With Garstin's report, despite its favoring cereal production, the cotton cultivation lobby was stimulated.

As mineral wealth appeared to be absent, the potential regional capital of the Sudan was to be found in the land with its crop production; the most certain way of increasing yields was by irrigation. In 1900, Governor-General Wingate had introduced the idea of irrigated cotton production in the Gezira creating irrigation revenues as a source of profit.[64] Gezira is an Arabic word, meaning 'island' or 'peninsula'. The word is not restricted to the Sudan, but in (modern) irrigation circles worldwide Gezira refers to just one thing: the vast triangle of irrigated land south of Khartoum between the Blue and White Niles. The Gezira Irrigation Scheme has become a kind of legend. Following his visit to the Gezira in 1946, Sayed Mohammed Afzal, Director of Research, Pakistan Central Committee, remarked:

> 'The Gezira Scheme is one of those outstanding experiments on socio-economic problems of the current century and its success is so great that it deserves to go down in history as a great romance of creative achievement . . . The rich fields and the smiling faces of the workers on the land, who were till recently nomads of the deserts, going back and forth eking out a miserable existence from an inhospitable country, are a running commentary on the success of this great experiment, and anybody who visits the Scheme cannot but be strongly impressed with the success of the experiment.' [65]

This 'experiment' is located in one of the flattest areas to be found.

> 'It would be difficult to imagine anything flatter than the great Gezira plain, two hundred miles long and eighty miles across' [66]

Covering an area of some 5 million feddan (one feddan equals about 0.4 hectare) sloping gradually from south to north, its most outstanding feature is

> 'its crushing monotony' [67]

The erratic rainfall could not ensure a crop year after year. Nevertheless, in years with good rainfall, cereal crops in the plain provided a good harvest. In years with little rainfall, waterwheels in the river watered narrow strips on the banks. This land was relatively cheap to irrigate.[68] Given the political circumstances and a lack of capital in the early 20th century, the Sudanese Government first focused on a number of smaller-scale flood irrigation projects not needing Nile water, such as those of the Gash and

Tokar deltas. Tokar proved to be the birthplace for one important feature of the future Gezira scheme: the delta was declared government land and each year allotments were made by the government to those who wished to cultivate.

> 'Tokar thus gave the Government its first experience of the immense advantage, to the budget and to the individual peasants, of an agricultural policy which both controlled and helped them.' [69]

Tenancy was the model to choose, enabling stronger control over farmers. Other test areas for the Gezira Scheme were the small-scale pump irrigation systems along the banks of the Nile in which the Sudanese Government and commercial growers laid the foundations of their future co-operation in the Gezira. In 1904, Leigh Hunt, an American, founded the Sudan Experimental Plantations Syndicate (SEPS), which was granted a cotton concession for 10,000 feddan at Zeidab, 180 miles north of Khartoum along the Nile.[70] In 1910, the Department of Agriculture proposed testing whether high-grade cotton could be produced in the area. As a result, in 1911 the Tayiba pump-irrigation project was established in order to grow long staple cotton and dura (sorghum vulgare). The Department did not have the personnel to manage the scheme, however, and the SEPS was asked to assume responsibility for managing the project. It accepted the offer and extended its operation to Tayiba.

Even with these favorable developments in Tokar and Zeidab, a powerful lobby of commercial cotton companies was needed to get the Gezira Scheme really underway. The reason for increasing interest in the Sudan was the situation in Egypt, where cotton production had been static for the ten years since 1900. The experiences at Tokar, but especially at Zeidab, showed that quality cotton production was possible in the Sudan. The influential Lord Kitchener of Khartoum

> 'displayed great personal interest in the Gezira and subsequently visited the plantations there on several occasions.' [71]

The British Cotton Growing Association (BCGA), founded in 1902 to promote growth of cotton in the British Empire, played a part in interesting the British Government and the Lancashire Cotton Industry in the development of the Scheme. The SEPS and the BCGA joined forces; in 1911 the BCGA took up 5000 new one pound shares in the SEPS and their chairman joined the board. The vast Gezira irrigation project became a concern of the British government when, after a powerful lobby of the British cotton industry, the government guaranteed a loan of three million pounds in 1913. World War I interrupted the plans, but in 1919 the area to be irrigated was set at 300,000 feddan. A delegation from the BCGA visited Gezira in 1919 to stimulate the construction of Sennar Dam and the irrigation system. A total of 13 million pounds was finally reserved for the project: £11.5 million for Sennar Dam and 300,000 feddan, £700,000 for railways and £400,000 for cotton ginneries.[72] In 1922, the contracts for dam and canal construction were given out and the work started. Confronted with huge cost overruns, but fearing the political and economic effects of abandoning the project, the British government guaranteed loans totaling almost 15 million pounds in 1924.[73] In 1925, the High Commissioner for Egypt and the Sudan, Lord Lloyd, officially opened the dam.

Sennar Dam, on the Blue Nile 260 kilometers south-west of Khartoum, supplies the canals on the left bank by gravity. Main canals are designed as regime conveyance channels, with water flowing continuously day and night. In the original design for the minor canals, practice from India and Egypt had been followed to maintain stability of discharge in the canal system by keeping the water flowing day and night. Farmers were expected to handle their ration efficiently whenever it came, even at night. The Gezira tenants, however, who

> 'had already accepted immense changes in daylight farming' [74]

were in the end not expected to be able and/or willing to irrigate during the night. Cutting off the water during the night, however, was not an option in a system the size of the Gezira; filling times would be indefinite. Uncontrolled water flows at night were not desirable either. Therefore minor canals were constructed as night storage canals. Cotton was the main crop in the Gezira, but other crops were also cultivated. Dura was the staple food crop; lubia (dolichos lablab) was grown as animal fodder. Agriculture in the system began with a three-step rotation: cotton, followed in the next season by dura and lubia each taking half of the field, followed in the third season by fallow. The dura and the lubia exchanged sides at regular intervals in order to maintain fertility. Grain and fodder were, like cotton, irrigated free of charge, and designated for the use of the tenant; marketing of the cotton crop was the responsibility of the Syndicate. Balancing one field outlet against another was essential to maintain stable discharges into the canal system. Without a strict timetable, the immense volume of water discharged into the main canal could not be evenly distributed over the network of canals; therefore a strict rotational schedule was designed and maintained. The irrigated area was divided into blocks, varying in size with boundaries reflecting the canal system. An average block amounted to 15,000 feddan; each had a block inspector and two junior field officers, who already had experience from the pilot stations. A group inspector supervised six to ten blocks. The field personnel responsible for the project was

> 'superimposed like the canal system itself on the life of the Gezira.' [75]

Such a structure, linking British inspectors directly to the farmers, was unusual for British colonial rule, usually referred to as 'indirect rule'.

A tripartite partnership with two main partners

In the meantime, the Government and the Syndicate had defined arrangements under which the Gezira Scheme would function. In 1919, a 'tripartite partnership' was formulated, stating the different responsibilities and gains of the three partners, with the 'tenants' as third party.

> The Sudan Government was responsible for Sennar Dam and received 40% of the total net profit from cotton production. The government rented the land from its official owners in order to let the land annually to tenants.
>
> These tenants, organized in farming units of 30 feddan, received 40% of the net profit but had to provide the production costs until cotton was delivered.
>
> The concession holder, the Syndicate, was responsible for scheme management and for providing field and accountancy staff, buildings, loans to farmers, and transport of the cotton; it received 20% of the net profit.

In 1921, the partnership was effectuated with the Gezira Land Ordinance.[76] In 1925, the Gezira cotton acreage consisted of 80,000 feddan; in 1926 this was 100,000 feddan. Because of the increase in costs, however, the Gezira Scheme became once again a point of discussion. The original 300,000 feddan already challenged Egypt's level of acceptance, but would still result in a recurrent loss. A larger acreage was needed. To cut a long story very short, political negotiations culminated in the Nile Waters Agreement of 1929. The Gezira would not draw more than 126 m^3/s before 1936. The Sudan and Egypt agreed in 1936 that the Gezira could receive 168 m^3/s in 1940; the final widening of the main canal to take this discharge was completed in 1956. Subsequent extensions steadily increased the command area to around one million feddan by the early 1950s. In 1944 it became clear that the Sudanese Plantations Syndicate's concession to operate the Gezira Scheme would not be renewed in 1950. In July 1949, a governmental Gezira Board took over the management. The Syndicate's 20% share of profits was to be used for research, social development and management costs.[77]

The Office du Niger, French Sudan, 1920 – 1964

The British may have been actively involved in colonial irrigation matters in Africa, but the French were not sitting still either. French engineers introduced one of their most challenging plans for irrigation in the inner delta of the Niger River, in modern Mali. There were actually two Niger Deltas, due to the river changing its course over time. The old delta, close to Sansanding, did not receive floodwater from the Niger. The new delta, originating at Diafarabé, was flooded annually in October up to 350 kilometers in length with a width as large as 100 kilometers, and an average surface of almost 20,000 km^2.[78] It was the old delta that attracted the attention of the French colonizers, because of its enormous potential for cultivable land and the presence of two old river branches, which could serve as main canals for an irrigation system. The region was an important area for the cultivation of cereals like millet and sorghum, as both crops could adapt to poor soils, low rainfall and dry spells. Farmers practiced flood recession agriculture, timing their activities to the rise and fall of the flood and the arrival of the rains. One of the greatest hazards for the delta farmers was the floodwater rhythm: when the floods arrived too early or too late, harvests were low. The French colonialists recognized that, despite its perceived high potential, the Inner Delta posed a number of problems, such as drought, locusts, and termites. According to the French, problems also were found in the

'prejudice and apathy of the Africans.' [79]

Nevertheless, many French people envisioned European-managed plantations worked by African laborers; development of irrigation-based plantations would increase the number of consumers with an improved standard of living to purchase manufactured goods which France wished to export to its colonies. The irrigated area in the Inner Delta had to provide these potential consumers with the necessary means to buy French goods. The goal was to equip about 1 million hectares in the central delta of the Niger River in Mali with irrigation. This plan has become known as the 'Office du Niger', the name of the French public enterprise created in 1932 to develop irrigation and settlement in the area.

Already in 1899, Emile Zola expressed the hope that the Niger, as it conquered the invading desert and created a fertile valley, would become the Nile of the French Empire[80]; the region was also seen as the

'Mésopotamie Nigérienne.' [81]

Both qualifications showed high expectations. In 1919, Emile Bélime, an engineer, travelled through the Niger valley to investigate irrigation possibilities.[82] Bélime had worked in French colonial Asia and had visited British India. In 1920 Bélime concluded that the Middle Niger area was highly suitable for irrigating cotton. He designed a plan to develop 1,850,000 hectares for pastures, legumes, rice, millet, wheat and cotton in the delta of the Niger River, as well as the vast areas to the north of it.[83] The program developed by Bélime served as the foundation for future projects aimed at exploiting the French Sudan.[84] The plans were included in those developed in 1920 by the Minister of Colonial Affairs, Sarraut. His central idea was 'la mise en valeur', or investment in public works instead of mere exploitation.[85] The plans included constructing transportation infrastructure, health programs and improvement of agriculture through irrigation.

Discussions on irrigation in the Niger delta before World War I focused on the apparent potential of the area to become as important a cotton growing area as British Egypt. Climatic conditions were perceived as favorable for cotton; an important factor would be regular water availability. With the development of British plans for Gezira, the French were even more convinced that the Office should be a centre for cotton growth. Results from pilot irrigated cotton schemes at El-Oualadji, close to Tomboctou (1917 – 1923), apparently confirmed the high expectations.[86] Although many actors involved had great expectations for the new irrigation scheme, not everyone was convinced that the Niger delta would fulfill such promises. The proposal of Bélime met with strong criticism. Bélime presented the colony as a potential region of incredible wealth, and gave the impression that

> 'Eldorado will be forthcoming once the irrigation systems are realized.' [87]

This optimism was based on the assumption that the Niger delta was comparable with the Nile valley. It was argued, however, that Egypt, with its ancient history of irrigation, and its much denser population was not to be compared with the Niger Delta. Furthermore, the Nile carried much more water, the floods were fertilizing the soils, and the distance to Europe was considerably less than from the French Sudan. Nevertheless, French colonial attention aimed at irrigated cotton production in the Niger valley. In 1922, an experimental station for cotton production was opened in Niénébalé, 50 kilometers south of Bamako. It was not too successful, reaching about 200 hectares. In 1925, the Service Temporaire des Irrigations du Niger (STIN) was created, which took over management.[88] The STIN constructed the Sotuba barrage to irrigate about 7500 hectares: 3000 for cotton, 3000 for rice and 1500 for pasture.[89] Opened in 1929, it served a main canal of 22 kilometers, with a maximum flow of 10 m^3/s. This first larger irrigation system in French West Africa was

> 'le champ d'expérience' [90]

for the Niger delta. The results in this area, including the colonization of more than 6000 people, were considered such a success that they opened the way for a program for the general development of the Middle Niger.

Cotton or cereals

Cotton played an important role in generating the Niger irrigation proposal, but the project included large areas for cereals, legumes and pasture for cattle too. Governor-General Carde stated in 1924 that the project's primary purpose was producing rice to end famine in French West Africa. World War I had shown the vulnerability of France and the colonies regarding food security. Adequate agricultural production should provide the colony with its own food – not just the Niger area, but also Senegal, which was no longer producing food itself because of the spread of peanuts, a cash crop of increasing importance to the French oil-seed industry. Thus, the food to be grown in the Office was part of the grander plan for imperial autarky. The aim of such a policy was threefold: to assure French industry of a supply of raw materials; to expand the market for manufactured goods; and to guarantee buyers in the colonial areas.[91] Raising the income of colonial subjects and enabling them to purchase French goods, or 'colonisation indigène', would generate an agricultural revolution in Africa.

The Niger valley irrigation scheme as the food source, the grain basket for French West Africa, was not inconsistent with the role this region had played before colonial occupation. Geographically and ecologically, the inland delta was well located for grain production. Rice, however, was never a major crop. The decision to include large areas in the Office for rice fits within French colonial policy favoring rice. Actions of colonial officials, such as tax collection in rice, stimulated an increased demand for the grain. As a result, both the cash crop cotton and the food crop rice were included in the Office design. Bélime and other advocates of the project planned to construct a large barrage at Markala, about 300 kilometers downstream from Bamako, diverting water to two old watercourses of the Niger through the Sahel and Macina canals. In 1929, Bélime presented an elaborate plan to the Minister of Colonial Affairs, proposing to irrigate 960,000 hectares: 510,000 for cotton and 450,000 for rice. The plan would need 300,000 settlers and would cost some 300 million francs, plus an extra 40 million for the colonization program. On March 16th 1931, the Minister of Colonial Affairs, Reynaud, gave his approval. On January 5th 1932, the organization to create and manage the irrigation system was officially established; the Office du Niger was an autonomous governmental organization. Construction of Sansanding barrage near Markala began in 1934 and was finished in 1947. The conveyance canal was designed with a maximum capacity of about 500 m^3/s. The Sahel Canal was completed in 1935, the Macina Canal in 1937. [92]

Irrigation was only possible when the annual Niger floodwaters filled the new canals. A provisional barrage was installed in 1941. One problem was that the irrigation scheme was designed using limited and sometimes incorrect technical information. The topographic surveys lacked the detail and precision necessary. An additional problem was the attraction of settlers. The Office should have drawn settlers from the French Sudan and Upper Volta. In the Sudan, however, demographic pressure was low, and in Upper Volta inhabitants generally preferred temporary migration rather than permanent settlement abroad. To reach an acceptable number of settlers, the Office used

> 'a certain amount of compulsion to recruit settlers' [93], or, stated otherwise,
>
> 'forcibly recruited most settlers.' [94]

The French government prohibited this practice after World War II. Many settlers fled from the project. Nevertheless, in 1945 about 20,000 persons had colonized some 22,000 hectares in two regions of the central Niger Delta[95], even before completion of Sandanding. Cotton cultivation proved to be difficult, however, as rainfall was plentiful and poorly timed for long-staple cotton. The poor results were the prompt for another effort to boost the scheme's development. The 'Commission de Modernisation et d'Équipement des Territoires d'Outre-Mer' proposed a 10-year plan (1947-1957) for the Office du Niger, during which 180,000 hectares should be developed: 105,000 for cotton and 75,000 for rice.[96] The execution of this plan would enlarge the existing area eightfold! In 1948 the Office resumed its development work in a new sector. Instead of assigning the new land to farmers, which were hard to find, the Office began to farm itself. Almost 6000 hectares were developed for rice near Molodo, and the autonomous enterprise 'Centre Rizicole Mécanisé' (CRM) was responsible for farming.[97] The CRM experienced such technical and economic difficulties, however, that it was abandoned in 1961 and its land allocated to settlers.

In 1957, the irrigated area in the Office du Niger covered a little over 47,000 hectares.[98] In 1960, at Mali's independence, 54,000 hectares had been developed.[99] Even if it did not fulfill its high expectations, the Office had become an enterprise with a comprehensive jurisdiction extending to commercial as well as administrative and agricultural questions. The Office was a public works contractor, an administrative service recruiting labor, and an entrepreneur concerned with agricultural production and supervising settlers. The Office performed all these roles and duties in an enormous area. The hectares that had been developed were scattered over several hundreds of square kilometers. The principal administration headquarters were at Ségou, 40 kilometers upstream from Markala; the Kolongo sector extended almost 150 kilometers towards the east from Ségou, and the Kourouma sector more than 200 kilometers towards the north from Ségou. The irrigation canals comprising the basic irrigation network covered a length of 280 kilometers. In 1955, the administration employed almost 7000 people. In 1964 it still retained a large staff of about 4700 employees. [100]

The irrigation factories of French Northern Africa, 1930 – 1956

Despite all the debates and developments in the Niger Delta, it was in the Northern African territory that the French colonizers developed the irrigation technique using concrete, raised canals constructed as a fixed grid erected over the area. The French colonial territories in the northern part of Africa include the present-day countries of Morocco, Algeria and Tunisia. Algeria is the oldest North African colony of France; it was already occupied in 1830. In 1881, the French invaded Tunisia, which was made a Protectorate in 1882. In 1911, thus much later, Morocco was included in the French North African colony. The area has a long history of irrigation. Technologies such as spate irrigation, oasis irrigation using water wheels, underground reservoirs and terraces were widespread. The concept of 'turns' was generally used, but written proof of water rights was non-existent and water shares were adapted each year[101]. The colonial administration could not function well in these circumstances.

In 1914 the French colonial government decreed that surface waters were public domain; in 1919 groundwater and marshlands were included. The gradual move to state control was further strengthened in 1925, when irrigation development was officially declared to be a state-led initiative, and private initiative was forbidden.[102] Two issues influenced the development of irrigation in the early 20th century: (1) what was the target group for irrigation, French settlers or native settlers; and (2) what was the target production sector for hydraulic engineering, irrigation or hydropower? In the first decades of the 20th century, French irrigation policy stimulated French settlement in new irrigation systems. If an area was suitable for irrigation, and the native population was small in number, the population would have to make room for the colonists. In areas with many natives, irrigation would not be developed. The turn came in the 1930s, due to a growing population, droughts and a more 'nationalistic' colonial government. Irrigation for native farmers became an important instrument in French colonial policy.

In the early discussions on irrigation, the French colonizers planned to produce wheat on a large scale in the North African region. The region was supposed to have been the 'Granary of Rome' or 'Eldorado'[103] during the Roman Empire, and the French liked to see themselves as the successors to this Empire. The wheat strategy was abandoned when climatic conditions appeared to be unfavorable and French wheat growers protested against the competition. The potential for cotton production in Morocco was also discussed: Indeed, the nascent 'granary of Rome' image was initially challenged by an 'Egyptian image'. Some noted that a native cotton industry formerly had flourished. One early authority claimed that wise harnessing of Morocco's rivers would convert Morocco into 'a little Egypt'; another described the Sebou Plain as a vast delta where cotton could generate untold wealth as it had in the Nile Delta.[104]

In 1917, a mission on the possibilities of Morocco supplying France with cotton, the Cosnier report, concluded that potential harvests were too low. Instead, French cotton growers developed activities in promising colonial areas, such as the Niger Delta. Disputes over which groups and sectors should be supported by irrigation and which department, Agriculture or Public Works, should lead the irrigation program caused a delay in the actual construction of irrigation schemes. With the government decree of 1925, the development process accelerated. The basis for the 1925 decree was a growing necessity for new lands. Most readily available water and land resources were used; new lands were needed for settlers from the region itself. The governor in Morocco advocated a focus on settlement, with less emphasis on 'mise en valeur'. In 1927, a central fund for irrigation was founded with a starting loan from the central government in France.[105]

Californication

Around 1930, 'la politique des grands barrages' was formulated. This was the first irrigation development program for Morocco and indeed North Africa.[106] Another crucial decision by the colonial government was to focus on developing high-value crops such as citrus, other fruits and vegetables. After Rome, Eldorado and Egypt, the rapidly developing irrigated agriculture of California, USA, served as the development model. Although the crisis in the late 1920s and early 1930s did not speed up developments, the Californian dream had taken off. In contrast with the older role models, the California model proved to be relatively successful. Morocco was not the only country to be influenced by California. Countries as diverse as Spain, South Africa, Argentina, Russia, Canada, and other French colonies such as Tunisia and Algeria, studied California's innovative fruit industry. In Morocco, however, the aspiration to create

> 'une nouvelle Californie' [107]

was particularly strong. As one Casablanca reporter proclaimed in 1931,

> ' [...] the reputation of California's wealth through irrigated agriculture is worldwide and it is so striking [...] because the majority of these crops have been developed on formerly worthless land, indeed on desert wastelands [...] Throughout the entire world the California example has attained the force of dogma, and symbolizes the modern miracle of irrigation.' [108]

> 'Their dream was to create a new California in Morocco. Struck by analogies of climate and natural conditions – as well as by the results of a dynamic irrigation policy that had succeeded in transforming a near-desert into a magnificent orchard, furnishing the entire world with choice fruits – settlers wanted to achieve the same miracle in Morocco.' [109]

Between 1929 and 1933 at least six French missions visited California. French commercial attachés and agents in California were involved in agricultural espionage. Agricultural methods, irrigation techniques, especially buried pipe systems and selected crop varieties were brought to Morocco. In 1938, a comprehensive irrigation plan for Morocco was defined in an attempt to respond to a number of issues, such as drought, the rise of a national movement and a growing population. An irrigated area of one million hectares was foreseen; implementing the plan would take a period up until the year 2000, and a new Irrigation Office should execute the plan. Between 1939 and 1956, large parts of the many plans for new schemes were not realized. In 1956, the year in which Morocco became independent, the country counted about 36,000 hectares with modern perennial irrigation, with a potential area served by existing dams of 250,000 hectares.[110]

Materializing a vision

Having a vision is one thing; creating irrigation systems based on that vision is something else. The Beni Amir irrigation scheme was a major test area for French irrigation engineering and one of the most important colonial irrigation schemes for the native population. Kasbah Tadla Dam, with the potential to feed a system of 45,000 hectares, and the main canal were constructed in 1930. The combination of a Californian dream, a colonial policy strongly focused on planning and control and a strive for efficient new irrigation schemes resulted in a highly regular irrigation landscape, consisting of a series of long strips planted with different crops, about 80 meters wide and 1000–1500 meters in length. The strips were perpendicular to secondary canals and parallel to tertiary ones. This regulated landscape was the result of a process of 'remembrement', land consolidation[111]. A pattern of small, dispersed holdings of irregular sizes and shapes created by population pressure and inheritance was transformed into a geometric landscape conforming to the requirements of what was defined as modern irrigation. The expropriation of existing holdings and the redistribution of them in regular rectangular parcels shaped the contours of the new canal network. This procedure had been introduced in 1935 in the Oulad Ziane experiment at Kasbah Tadla and was extended to the Beni Amir irrigation perimeter in 1937.[112] Consolidation was an important instrument to the French to reach their goal

> 'to make an occasional farmer an 'intensive farmer'.' [113]

It was a vision of a rationalized landscape composed of the lush, rearranged, privately owned parcels of peasant farmers, who would grow crops required by the state according to a rigid, predetermined production plan and adhering to strict rotation schedules. These settled people would be supervised and assisted by the government, but they would be fully charged for water to ensure the economic viability of the development scheme.[114] Within a highly regulated irrigation landscape, water delivery to the field could not be other than regulated. The earthen canals of the 1930s did not perform according to standards, with canals being long in relation to the irrigated area and water losses considered too high. Attempts were made to modify the canal system, but the real breakthrough from an engineering point of view came after World War II. In that period of renewed modernization in Morocco, Algeria and Tunisia, the Beni Amir system covered about 18,000 hectares with canals dug out of earth.[115]

In 1947, 1600 hectares, and 2800 hectares in 1949, used the type of canal that made French irrigation engineering famous: concrete, semi-circular raised canals.[116] The availability of pre-fabricated, reinforced concrete elements with a length of 6.80 meters and diameters of 30–185 centimeters enabled French engineers to restructure the landscape completely. The canal system became virtually independent of available slopes and landscapes, as the canal supports could be adjusted in height to arrive at the optimal slope and layout. The

> 'friendly disorder of the old perimeter with its English park style' [117]

was tempting, but

> 'technicians preferred the long straight lines in the style of an immense French garden.' [118]

Colonial Production Regimes

The Gezira scheme, developed with input from British engineers with working experience in India and Egypt, served as a point of reference, or competition, for

French irrigation activities in the Niger Delta. The French tried to construct their own Gezira scheme; they were not successful in the Sudan. It was in North Africa that the French engineers created their own success. With inspiration came from American ideas, the systems in North Africa were developed along similar lines as in both the French and British Sudan. The colonial African irrigation systems share many characteristics of an imposed production regime. The farming community was expected and often forced to cultivate what and how the colonial management prescribed. Not only was the farming community to act according to prescription; the landscape had to be changed into a new, modern and particularly geometric form. In the same way as they could transform the landscape, the colonial powers could also force peasants to grow certain crops, or organize the management of facilities, as they considered best. However: the degree of control exercised by the central irrigation authorities, and their manipulative powers with respect to agricultural improvement, were limited. This has to do with the larger scale of many canal schemes and the administrative framework in which they operated. Furthermore,

> 'colonial rule was always a juggling act' [119]

between available labor from colonizers and colonized, available financial resources and political goals.

Accepting the general applicability of the juggling act metaphor to colonies worldwide, one can distinguish differences between colonial irrigation policies in territories with recognized histories of irrigated agriculture, recognized by the colonial powers that is, such as British India, Egypt and the Netherlands East Indies, and territories without such recognized histories, for example the French and British Sudan. Whether such differences in guiding principles are solely products of the Eurocentric framing of non-European histories remains to be studied, although there is material to support the argument that Eurocentric framing has been a determining factor. Africa was often described by Europeans as a continent without history, whereas the East has long been a source of inspiration for Europeans. In 1965, the English historian Hugh Trevor-Roper wrote that African history had nothing more to offer than

> 'the unrewarding gyrations of barbarous tribes in picturesque but irrelevant quarters of the globe.' [120]

Although many Europeans considered the East as below European civilization, Eastern civilizations was recognized, seen as stagnating, and their pasts were studied extensively.

> 'Towards Africans the attitude was very different. For them the image of an important, old, but later stagnated civilization did not exist. On the contrary, for centuries the African was considered as backward, primitive, barbarian.' [121]

I will show in this book that in the Netherlands East Indies several rather strict management principles and systems were developed. Irrigation scheme management in these Indies, however, restricted itself mostly to water management and did not attempt to manage complete production processes as in the colonial irrigation systems in Africa. East Indian farmers in general were landowners, or at least not tenants of the irrigation agency. Farmers on African schemes were tenants, not landowners. Dutch colonial settlement schemes, which mainly developed in the 1930s, were planned by a top-down perspective, which is obvious in a colonial context. Nevertheless, the future farmers were treated as future owners, different from Africa where people were treated as having no relevant history in an area likewise without relevant history. The East Indian settlements aimed to recreate the Javanese village in new areas, to recreate a better history and not to create a completely new modern reality, as was the case in Africa.