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Empirical Knowledge, Scientific Authority, and Native Development: The Controversy over Sugar/Rice Ecology in the Netherlands East Indies, 1905–1914

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ABSTRACT

This essay explores the political value of empirical, scientific knowledge of place in the Netherlands East Indies. Critics of the European sugar industry claimed that sugar depleted the soil and stunted subsequent rice crops. The ensuing controversy reached a stalemate when both sugar scientists and their critics were accused of selectively choosing evidence according to political bias. Scientists in the Department of Agriculture resolved the dispute and fought accusations of bias by drawing on their empirical knowledge of agricultural conditions across Java, using place-based knowledge to construct their credibility and exclusive authority to speak for agricultural matters in the colony.

KEY WORDS

Colonial agriculture, colonial science, rice, sugar, Indonesia

INTRODUCTION

In the Madiun¹ region of central Java in 1903, the *Binnenlands Bestuur*, the colonial civil service, reported complaints from indigenous farmers who regularly worked their land in rotation with European sugar planters. Farmers claimed that sugar growers were ruining the land by using chemical fertilisers on the cane crop.² The Resident, the head of the *Binnenlands Bestuur* for the region, had been sufficiently alarmed by these complaints in light of recent declines in rice and peanut production that he contacted Melchior Treub, the highly respected head of the Royal Botanical Garden in Buitenzorg.³ Treub acknowledged the



MAP 1. The Netherlands East Indies

possibility that chemical fertilisers could have created some problems in soil fertility as such effects were well documented in Europe. If declines in rice and peanut production had occurred, then it was certainly possible that the chemical fertiliser favoured by sugar planters, sulphate of ammonia, was to blame. The Resident accordingly suggested that Madiun planters immediately forego the use of chemical fertilisers and switch to natural alternatives.⁴ J.D. Kobus, a prominent sugar scientist, denied that fertilisation practices had produced negative effects. He claimed instead that rice yields usually improved as a consequence of rotation with sugar, and recommended that sugar planters continue as usual.⁵

For ten years, the ecological relationship between sugar and rice crops, when these were grown in rotation, remained a controversial subject, pitting scientists from the East Java Experiment Station of the General Syndicate of Sugar Manufacturers⁶ against scientists from the Netherlands East Indies Department of Agriculture. What made the controversy particularly difficult to resolve was both the complex and contradictory nature of the data, and accusations of bias on both sides that hampered any consensus-building on interpreting that data. Some critics in the colony and in the Netherlands had long accused sugar planters of practices that impoverished local farmers; these critics believed that any result coming from scientists working for the sugar industry would be biased conveniently to overlook harm to local communities.⁷ Supporters of the sugar industry, on the other hand, felt that such criticisms were unfair and took

an unduly skewed view of the best interests of farmers, ignoring the positive economic contributions of sugar plantations to the regions. In the view of the sugar industry, narrow-minded critics would unduly weigh the value of isolated negative cases and ignore the places where rice crops had remained strong in rotation with sugar.

At issue was not merely the ecological effects of sugar cane on subsequent rice crops, but the question of who had the credibility to interpret this relationship reliably. For those who were suspicious of the sugar industry's motives, the Department of Agriculture, which had been formed with the explicit mission to improve indigenous agriculture, seemed most likely to remain impartial.⁸ On the other hand, the sugar industry had built a respected scientific institution in East Java, and sugar scientists bolstered their interpretive credibility by arguing that they had a superior understanding of the day-to-day conditions of cultivation on Java. The rotation of sugar and rice on the same land blurred the boundaries between European and indigenous production. In the same way, the controversy over the ecological relationship between rice and sugar called into question the seemingly clearly demarcated boundaries of scientific authority in the colony.

The perception of political or economic interest biasing interpretation made scientific credibility the important underlying issue of this debate. Claims to superior empirical knowledge of conditions on Java became the favoured strategy for asserting the credibility of scientific claims and claimants. This paper explores how and why superior empirical knowledge became a critical tool for combating accusations of bias and for conferring interpretive authority in an otherwise intractable debate.

SUGAR, RICE AND THE ETHICAL POLICIES: BACKGROUND TO THE CONTROVERSY

The system of rotating rice and sugar on the same land reached back to the mid-nineteenth century, when a system of production called the Cultivation System was the colonial government's main source of revenue. Under the Cultivation System, villages were required to grow certain export crops mandated by the colonial government in lieu of taxes. The government auctioned off these crops, making a healthy profit.⁹ Under this mandate, villages in regions where sugar grew best added sugar to their customary rotation of rice and other dry season crops. By 1870, the advent of more liberal thinking in the Dutch government motivated a change in policy, and reformers passed a number of reforms that were meant to remove the government from export production. Dutch liberal reformers argued that the Cultivation System was outdated because the government interfered too much with trade that would operate more efficiently in the private sphere. The Sugar Law of 1870 mandated that the government would gradually withdraw from sugar production, opening Java to private investment



FIGURE 1. Indigenous labourers prepare cane for planting. (J. Sibinga Mulder, *De Riet-suikerindustrie op Java*, N/V H.D. Tjeenk Willink & Zoon, 1929, p. 23.)

in 1878.¹⁰ At the same time however, reformers wished to safeguard Native peasants from predatory practices of wealthy European or Chinese investors.¹¹ The Agrarian Law of 1870 guaranteed that Natives in possession of land would maintain their customary rights, and that they could, if they chose, obtain the right to private ownership.¹² A further ordinance in 1875 formally mandated that Native lands could not be alienated to non-Natives.¹³ Forbidden from owning land, European investors had to lease land from individuals or villages in order to grow sugar crops on Java, and could not require that land be taken out of rice production for too long. Private sugar planters therefore had to accommodate their needs to those of the villages, and their cane planting to rotation with rice, which had become, under the Cultivation System, ordinary practice.¹⁴

A sugar manufacturer would negotiate leases with a number of villages in order to gain access to a large contiguous block of land. The lease ran for 21½ years, and during that time a typical rotation was sugar cane for 15–18 months, followed by rice, a dry season crop like peanuts or maize, and a second rice crop.¹⁵ While not allowing sugar planters continuous and sole access to (and control over) the land, the system did give them access they might not otherwise

have had to land that was ideally suited for sugar cultivation. Both rice and sugar thrive when there is good and well-controlled access to water, so the flat, rich, and well-watered valleys where wet rice, or *sawah*, agriculture was most successful were the same places that made the best locations for sugar planting.

Because of the similar needs of the two crops, colonial agricultural experts tended to view rice and sugar as complementary, at least ecologically. Sugar planters frequently ploughed more deeply than did indigenous farmers, and on some soils this provided an improving effect for subsequent crops as well as for the sugar itself.¹⁶ The theory of rice/sugar complementarity was, however, primarily grounded on the basic assumption that greater access to water improved rice harvests.¹⁷ Colonial officials tended to view new irrigation works, which were promoted and sometimes partially funded by sugar manufacturers, as equally beneficial for indigenous farmers.¹⁸ Deeper, scientific studies of the effects of sugar on rice harvests were rare before the turn of the twentieth century.¹⁹

While many Europeans assumed that the ecological relationship between rice and sugar was harmonious, they would not make the same claim about the social and economic relationship between rice and sugar growers.²⁰ Indeed from the onset of private sugar planting, the relationship had been contentious and the object of much criticism among reformers in the European community. Despite the assumption that irrigation works would benefit everyone, rice farmers and sugar planters often contested the distribution of irrigation water. Towards the end of the nineteenth century, sugar planters adopted new sugar processing technologies that used more water, exacerbating these conflicts.²¹ Government regulations that partitioned water by day- or night-use eased, but did not resolve, the conflicts.²² More contentious over the long term were the linked questions of rent paid by sugar planters to farmers for use of their land, and the wages paid to field workers who provided seasonal labour while land was planted to sugar.²³ The amount of land rent was based on the estimated value of the rice harvest that farmers would forego. Because sugar was a much more valuable crop than rice, sugar planters stood to make good use of their investment in land rent, despite their complaints about the system. Indigenous farmers, on the other hand, frequently entered a cycle of debt, in which they spent their rent payments early in the three-year crop rotation, leaving them vulnerable to loan sharks and pawn shop operators for later shortfalls. Sugar planters also came under fire for paying low wages to workers – most of whom needed hard cash to pay their tax obligations. Sugar planters emphasised the good they did in bringing wage labour to the indigenous people. Opponents of the sugar industry accused them of exploiting a population who had become caught in a cycle of debt. Sugar planters were known to bribe the village leaders with whom they negotiated to get more favourable terms for themselves, a practice which left ordinary people at the mercy of both the sugar planters and their own leaders.²⁴

The problems in the sugar/rice regions gained increased political visibility with the formal advent of what became known as the Ethical Policies in 1901.

These policies, which bore a family resemblance to civilising missions elsewhere in the colonial world, declared that the government of the Netherlands East Indies was obliged to work actively to improve the welfare of the indigenous peoples.²⁵ While the Ethical Policies advocated far-reaching reforms in many aspects of public life (for example greater press freedoms, freedom of political organisation for indigenous people, and more widely available education), they contained a significant technological component as well. The earliest Ethical planners argued that the lives of indigenous peoples could be improved if their technologies of production (primarily agricultural, as most indigenous people worked in agriculture) were made more efficient. The slogan 'irrigation, education, and emigration' captures the initial technological thrust of Ethical thinking: adding new irrigation works to improve harvests of indigenous crops (especially rice), educating mid-range officials, farmers and trades people in new, more productive ways of working, and encouraging farmers to emigrate from the crowded and subdivided lands of Java to the Outer Possessions where they would establish prosperous, rice-farming communities.²⁶ The Department of Agriculture was established to address shortcomings in indigenous production. Like civilising mission projects elsewhere in the world, the government took the responsibility of both identifying the main problems of indigenous society, and devising solutions, a process that came to be called 'the development of the Native peoples'. The existing conflicts in the rice/sugar lands gained new political visibility with the advent of the Ethical policies.

SUGAR YIELDS, RICE YIELDS AND THE QUESTION OF CHEMICAL FERTILISERS

While the ecological relationship between rice and sugar had not played much role in the earlier discussions about the effects of the sugar industry on indigenous farmers, in 1905 Zeno Kamerling brought the subject into public debate in a thirteen-part series of articles published in the *Soerabaiasch Handelsblad*, a general interest newspaper published in Surabaya, East Java.²⁷ Kamerling was a former employee of the sugar industry, working at the Kagok sugar experiment station on Java. During his tenure there, he had argued vehemently against the sugar industry's use of sulphate of ammonia fertilisers, claiming that these fertilisers degraded the soil and that natural manures were superior.²⁸ Although he had left the sugar industry to take up a position teaching natural science at a European academy in Batavia, he continued his campaign against standard fertiliser practices in the sugar industry with the articles in the *Soerabaiasch Handelsblad*. Kamerling asserted that the use of sulphate of ammonia fertiliser on sugar cane caused nitrogen depletion and structural damage to the soil. He further posited that this fertiliser greatly increased the cane crops' uptake of nitrogen, providing short-term yield improvements for sugar, but at the cost of

long-term nitrogen depletion of the soil.²⁹ As evidence he pointed to the declines in the rice and peanut yields of indigenous farmers in the region of Madiun.

In Kamerling's earlier work on the topic (in 1900), he argued that protecting the soil (by not using sulphate of ammonia) was in the best interests of the sugar industry. He had little to say about the effects on indigenous farmers.³⁰ Perhaps motivated by the debates over the Ethical policies, Kamerling changed focus in his 1905 newspaper articles by putting the needs of the indigenous people on equal footing with the long-term health of the sugar industry, and highlighting the consequences of soil depletion for the yields of indigenous rice fields. Despite its specialised and technical content, the editor found the topic of enough general interest to put each instalment of the article on the front page of the newspaper. Kamerling therefore had a relatively large audience, as he subtly transformed the earlier discussion about the technological practice of fertiliser use in sugar growing into a broader discussion about the ecological relationship between rice and sugar production.³¹ Kamerling scrutinised the technology of sugar production as an issue with Ethical implications, in effect opening up the 'black box' of sugar manufacturing for the general public (where a black box is a technology not widely understood by non-experts).³² Rice agriculture became both key evidence of soil degradation, and the central motivation for immediate change. For Kamerling, rice agriculture needed to be understood as the canary in the coalmine. Sugar cultivation had changed over the years, with improved methods masking the degraded fertility of the soil, he claimed, while indigenous rice agriculture was being practised as it always had. Therefore, rice agriculture ought to provide the earliest evidence of decreased soil fertility, and Kamerling claimed the situation in Madiun proved just this.³³ The consequences for rice agriculture were serious, Kamerling argued, because the very difficulty of changing indigenous practices meant that decreases in fertility would devastate indigenous agriculture quickly, and possibly irreversibly. Solving the problem could not wait for the declines to show up in sugar production.

Kamerling's strenuous insistence for immediate action was hampered by the weakness of his evidence. Indeed, Kamerling admitted that direct evidence of a decline in fertility over the previous thirty years was lacking. Many sugar producers showed a steady or even slightly increasing production of cane sugar during that time, which Kamerling attributed to factors that he argued masked the slow decline in soil fertility: more intensive and deeper cultivation of the soil, cultivation of larger areas, heavier use of fertilisers, and new canes.³⁴ Lacking evidence from the sugar industry, Kamerling marshalled indirect evidence to make his case. In addition to the declining rice yields mentioned earlier, he also pointed to European examples in which the sole use of sulphate of ammonia for other crops, specifically barley, had led to serious soil degradation.³⁵ The European example was of special importance to Kamerling because it resulted from forty years of experiment and observation, and therefore showed the decline even though it was quite gradual. To make the link to sugar he cited studies of

sugar production in the West Indies, made by F.A.F.C. Went, a well-known and respected Dutch scientist. In Surinam especially, Went concluded that a steady decline in soil fertility occurred after about seven years of continuous cultivation of cane.³⁶ These cases served not only as evidence against sulphate of ammonia, but as cautionary tales – by the time undeniable direct evidence was available, it might be too late to prevent ecological and economic disaster on Java.

Not satisfied simply with showing soil degradation, however, Kamerling asserted that rice was a soil improving crop, which made the Ethical implications of the rice/sugar relationship even more clear. While sugar cane, with the help of sulphate of ammonia, would remove nitrogen from the soil, the silt from the irrigation water used in flooded rice agriculture added nitrogen back to the soil.³⁷ By the time the land recovered to some degree from nitrogen depletion, it would be time to rotate back to sugar production. In essence Kamerling was demonstrating that not only did wealthy sugar planters harm the yields of poor, indigenous rice farmers, but the rice farmers were in fact ecologically subsidising sugar production.

FINDING THE TRUTH: SCIENTIFIC BIAS, THE SUGAR INDUSTRY, AND THE DEPARTMENT OF AGRICULTURE

As this was not the first time Kamerling had raised this issue, the sugar industry had already proposed a way of resolving the question. J.D. Kobus, the prominent sugar scientist who would spend the next several years debating the issue with Kamerling, had proposed that the sugar experiment stations, with witnesses from the *Binnenlands Bestuur*, run a series of experiments to determine whether or not sulphate of ammonia was indeed creating problems in soil fertility. Kamerling took issue with this proposal in his article, bluntly claiming that the sugar industry was too biased to be trusted with such important work.³⁸ He argued that only the Department of Agriculture (despite its youth, having only been established in January of that year) could put this research on an unbiased footing, and then only if they committed to repeating the experiment over many years, as had been done in Europe. Kamerling doubted the ability and desire of the *Binnenlands Bestuur* and the sugar industry to interpret the evidence properly:

In the best case they might continue for four years or so, (while as the research in Europe teaches, such experiments must continue for thirty or forty years to get convincing results) and then they should conclude, on the basis of four years of negative results, and contrary to all practical experience in all other countries, that the exclusive use of chemical fertilisers does no harm.³⁹

Such an accusation of bias was certainly not surprising. Even Kobus acknowledged the sugar industry's appearance of interest in the outcome when he suggested

that the fertiliser experiments be witnessed by the *Binnenlands Bestuur*.⁴⁰ The naming of the Department of Agriculture as an unbiased scientific authority did not go unchallenged by the sugar industry, however, whose members did not regard the government as disinterested, but rather as carrying their own biases which might shape their interpretation of the data.

The young Department of Agriculture, while created by the government to serve the interests of the entire colony, had yet to earn unanimous recognition of its own authority and credibility. One critic complained to the Seventh Sugar Congress in 1905 that sugar planters knew their own regions far better than representatives of the civil service, whose officers came and went, and who relied naively on informants without knowing the real situations within the villages. The same criticism was easily levelled against the Department of Agriculture. For this critic and others, the closeness of sugar planters to the situation in the villages was an advantage that government departments did not have. In this view, their closeness allowed them to interpret local complaints critically; planters clearly viewed themselves as best placed to analyse and correct the complicated social and economic problems of the sugar/rice villages.⁴¹

The primary reason that sugar planters accused the government of bias was the government's particular attachment to the notion of Native development through improvements to rice farming. For many critics, improving the social welfare of the Native people needed to be understood more broadly than simply improving Native agricultural practices.⁴² The Department of Agriculture had focused their efforts (and pinned most of their hopes) on improving the productivity of rice agriculture, the most widespread economic activity on the island of Java.⁴³ Opponents claimed that improving welfare through rice farming would never work, because rice farming simply would never pay.⁴⁴ In this view, the sugar industry, by offering paid employment, as well as opportunities to make money through support activities like transportation, was essential to the welfare of the farmer, who would never make ends meet on rice alone. The implicit critique from the sugar industry was that the colonial government was biased towards keeping rice farmers operating as rice farmers. The sugar industry feared that anything that was perceived as hurting rice farmers would not get a fair hearing.

The fear of government bias was exacerbated by the publication in 1907 of the first volumes of the *Investigation into the Declining Welfare of the Native Peoples*. In the section of the report that looked at sugar villages, the authors noted the widespread belief (among indigenous farmers) that sugar planting caused a decline in rice yields.⁴⁵ Some disputed the truth of the *Investigations*. In the November issue of the *Indische Gids*, one critic questioned the veracity of the statistics used in the *Investigations*, suggesting that they were 'taken out of the air' and that they demonstrated the subjective beliefs of the reporters while maintaining a veneer of objectivity.⁴⁶ Further, the author stated that H.E.

Steinmetz, the chair of the committee that produced the report was ‘a long-time, known opponent of the sugar industry, whose views come to the fore in the list of questions [asked of village heads]’.⁴⁷ The author goes on to wonder how many of the reporters came under the chair’s influence, and as a result perhaps even generated fictional numbers. Despite this sort of criticism, the Minister of the Colonies in the Netherlands strongly backed the reliability of the *Investigations*.⁴⁸ Supporters of the sugar industry maintained, however, that government officials might have their own anti-sugar agenda that coloured their interpretations, or perhaps even led to falsification of the data. In the matter of the relationship between sugar and rice farming, neither side in the debate believed that the facts of the matter could be reliably determined by those on the other side due to economic or political biases. To resolve the question, investigators had to find some way to demonstrate that their evidence was unbiased. Empirical knowledge became the most important weapon in this dispute.

LOCAL KNOWLEDGE AND EXEMPLARY CASES

In a blistering initial response to Kamerling’s attack on the sugar industry, Kobus, the scientist who spoke for the sugar industry in this dispute, dismissed nearly every aspect of Kamerling’s critique by questioning Kamerling’s empirical knowledge of Java.⁴⁹ To understand what was happening on Java, Kobus claimed, one needed to understand specifically Javanese circumstances and not use examples from Europe or elsewhere as Kamerling had done. Kobus argued that Kamerling’s ‘doubtful evidentiary procedures’ led Kamerling to see evidence from Europe and the West Indies as properly exemplary for Java, when in Kobus’s view it was not:⁵⁰ ‘The European circumstances which he uses for comparison, diverge so entirely from that which prevails here on Java, that conclusions based on this are entirely worthless for us.’⁵¹

Kobus’s accusation of questionable evidentiary practice was certainly meant to suggest that Kamerling was either incompetent or a biased opponent of the sugar industry (or both), but Kamerling was not in fact doing anything unusual when he claimed that fertilisers would behave in an approximately similar manner anywhere, whether Europe or Java. When establishing matters of fact, scientists must always construct which factors (including place) will be relevant to a particular phenomenon and which will not.⁵² Such claims of similarity are, however, frequently called into question during controversies, and are especially easy to question in cases of agricultural experiment or observation, given the normal ecological variability of soil, water, and climatic conditions.⁵³ Kobus disputed the assumption of similarity by highlighting the differences between Java, Europe and other sugar colonies: the significance of flooded rice agriculture and the sugar/rice rotation for the condition of the soil.

He claimed that the periodic flooding of the land with nutrient-rich irrigation water, in combination with a rotation that kept sugar on the land for only eighteen months in three years made the Javanese situation unique and comparable to neither Europe nor the West Indies. Any detrimental effect inherent in sulphate of ammonia alone would be more than compensated for by the periodic benefits of flooded rice agriculture.

Kobus did not stop there however. He dismissed Kamerling's evidence from Java as well, again on the grounds that the evidence chosen was not exemplary – that is, it was incapable of representing the true situation on Java as a whole. For example, Kamerling had used some data from a sugar scientist to show that the all-important silt in irrigation water usually had a deficit in calcium needed by the crops.⁵⁴ Kobus criticised that data as being based on too limited a sample size, and being far less valuable than his own data which had been taken daily from five rivers in Java.⁵⁵ It is important to note that Kobus did not dispute the importance of empirical evidence in resolving the question. Rather he disputed whether the evidence used could be considered exemplary. He noted, irascibly: 'When someone so rashly judges an entire method of cultivation, he ought to at least be up to speed on the correct investigations.'⁵⁶

Kobus offered evidence to counter Kamerling's claims, evidence that he presented as being truly exemplary of the particular circumstances of the rice/sugar rotation on Java. His strongest counterexample came from tests run in 1904 at a sugar plantation in East Java. The planter involved reported that in the region of his plantation, all the areas that had been planted to sugar had subsequently produced dramatically higher yields of rice than those lands that had never been planted to sugar.⁵⁷ Kobus attributed this gain to the positive effects of the deeper ploughing practised by the sugar plantations. That is, when sugar planters prepared the land for the cane crop, they ploughed twice as deeply as did indigenous farmers. When the land was returned to the rice farmers, they would gain benefits from this deeper ploughing. Kobus added evidence from a Native regent in the area of Sidhoarjo, who claimed that yields had nearly doubled in the previous thirty-five years in his region, supporting the contention that the deeper ploughing practised by sugar factories improved the soil, and thereby increased subsequent rice yields.⁵⁸

To what extent did Kobus wish to position these as exemplary cases? He was careful to conclude his critique of Kamerling by stating, 'Establishing the facts through well-done tests is the main thing, and when we are careful not to generalise, we shall slowly reach our goal of improving agricultural knowledge and therefore the Java sugar industry and Native agriculture.'⁵⁹ Despite this balanced wording, Kobus uses more definite language earlier in his article saying 'The alleged decline in yields of rice after fertilising cane with sulphate of ammonia was shown ... [through the East Java experiments] to be impossible.' In a discussion on the topic that took place in the Seventh Sugar Congress in

April 1905, Kobus said confidently: 'With regard to the connection between rice harvests and sugar cultivation, I can supply some statistics, that show that the sugar industry has a favourable influence on rice yields.'⁶⁰ His lack of conditional language suggests that Kobus did indeed want to assert his own evidence as essentially 'normal', that is, exemplary for the conditions of the sugar/rice rotation on Java.

Establishing the exemplary value of cases proved to be difficult on both sides of the debate. Kobus did not manage to build a consensus of opinion around his own cases, even within the sugar industry. During the discussion at the Seventh Sugar Congress, one planter who had seen rice yields drop by almost one half in his region, responded to Kobus by arguing: '... The numbers cited by Kobus cannot serve as material for comparison. We must account for the situation as it is, not as we wish it to be.'⁶¹ The claims in the *Investigations into the Declining Welfare* also continued to spur discussion on the subject, but without building any consensus that the cases there were exemplary either. One supporter of the sugar industry, a planter named H.J.W. van Lawick expressed his own frustration at the explosion of contradictory evidence by asking how anyone was supposed to tell which cases represented the normal situation and which did not.⁶² Complexity of evidence was certainly a problem, as no easily discernable patterns had emerged in the investigations. But complexity was not the only issue, as the question of interests or bias continued to be discussed. How could one be sure that the scientists who chose the cases were not merely choosing them because they fit preconceived beliefs? Van Lawick's proposed solution pointed to the general concern over the problem of bias. Despite his strong belief that experiments would eventually vindicate the sugar industry, he argued that only the Department of Agriculture could resolve the question, and then only if the experiments were personally overseen by Melchior Treub, perhaps the most famous scientist in the Indies, and a man whose reputation for impartiality on scientific matters was readily accepted by most of the European population.⁶³ Individual authority, however, would not resolve this debate.

Kobus dismissed the notion that only the Department of Agriculture could make a credible experimental inquiry, and organised his own series of experiments between 1906 and 1908 to study the question.⁶⁴ He tested a number of different crop rotations on the same land using small plots with different fertiliser inputs to gauge the results of fertiliser use on yields of various crops. While rice did consistently more poorly after sugar fertilised by sulphate of ammonia, the declines were fairly small, and Kobus argued that they were almost within the range of acceptable error for the test.⁶⁵ Perhaps the most decisive result of the three year series of tests was that access to irrigation water seemed to have a much more dramatic effect on all the crops than the particular crop rotation.

OMO MENTEK IN MADIUN: THE DEPARTMENT OF AGRICULTURE ENTERS THE DEBATE

Until 1910, the Department of Agriculture, despite calls to act otherwise, stayed out of the controversy. Events in the region of Madiun in 1910, however, brought the question of the rice/sugar relationship to the fore within the Department. During 1910 the area around Madiun had experienced serious outbreaks of *omo mentek*, a disease whose origins were unknown at the time.⁶⁶ Rice plants infected with the disease withered and gave little or no grain.⁶⁷ By responding for the Department of Agriculture to the situation in Madiun, a third player entered the debate started by Kamerling and Kobus, a young botanist named P. van der Elst. Because many outbreaks had occurred on land regularly rotated with sugar (as much of the land in Madiun was), van der Elst took a fresh look at the question of the effects of sugar cane on rice agriculture, asking whether cane cultivation might make the rice crop more susceptible to the disease. While van der Elst reported very thoroughly on other aspects of the disease, he gave most attention to rice rotation practices, including the rotation with sugar.⁶⁸

Van der Elst demonstrated a link between nitrogen-poor soil and the occurrence of the disease, and asked whether certain rotations resulted in nitrogen exhaustion in the soil. Citing, and rejecting, the findings of Kobus, van der Elst concluded that nitrogen deficits were common on soils where sugar and rice were worked in rotation. Such deficits were only avoided under conditions of very strong irrigation on particularly good soil.⁶⁹ Regardless of fertilisation practices, the soil on which sugar was rotated with rice showed noticeable deficits in nitrogen content even a year after the harvest of the sugar crop, despite the flooding that accompanied the rice crop during that time. *Mentek* appeared much more frequently on the nitrogen deficient soils than it did in areas where irrigation was stronger and silt content higher in that essential nutrient.

For the purposes of this essay, van der Elst's method of resolving the debate is more important than the fact that he did resolve the debate. He managed to assert his claims as both credible and authoritative in a way that the exemplary cases of Kobus and Kamerling had not. Van der Elst repeatedly emphasised the breadth and reliability of his empirical knowledge of the region of Madiun, as compared to the work of either Kobus or Kamerling, and played down the idea of normal or exemplary cases. Instead he foregrounded the interplay of different factors that contributed to the seemingly contradictory situations across Madiun, drawing an interpretation that highlighted rather than erased the complexity of the results.

Van der Elst gave a detailed explanation of the many sources of statistics he used to build his case.⁷⁰ The multiplicity of his sources of data, and the role of personal experience in compiling and verifying all of this data figured prominently in his description of his research methods. He consulted the *Binnenlands Bestuur* for reports on the recent harvests, the head of the local irrigation districts

for information on the strength of irrigation in the area, the meteorological service for weather data, and village heads and farmers for anecdotal reports of the disease. Not relying on second-hand accounts alone, he visited most of the villages, many more than once, to track the progress of crops and disease during 1910, adding the veracity of a scientific witness to these many accounts. He made sure to let his readers know that he had collected data from every village in Madiun, not just a few, and that he cross-checked all of the data himself with his other sources of information to be sure that it was accurate.

The claim he built by doing so was about coverage, a deep empirical knowledge of the entire region of Madiun, not just a few isolated and possibly opportunistically chosen areas. Unlike others who could be accused of picking and choosing data to suit their interests, by compiling so much data on the entire region of Madiun van der Elst bolstered his own assertions of objectivity. He criticised Kobus's experiments in comparison with his own analysis, accusing Kobus of drawing incorrect general conclusions about the effects of sugar on rice from too few examples, because those few examples could only match a few local conditions, and could not account for others.⁷¹ For van der Elst, the scope of Kobus's knowledge was inadequate to draw useful conclusions about the complex relationship between land, water, and soil that defined the rice/sugar rotation.

Drawing on the Madiun study, van der Elst published in 1913 a more direct and cutting response to Kobus in a sugar industry publication.⁷² Van der Elst again argued that only comprehensive empirical understanding of the varying ecological circumstances in the rice/sugar regions on Java could produce a reliable interpretation of the relationship between rice and sugar growing.⁷³ In this later essay, van der Elst directly challenged the credibility and authority of Kobus in ways he had only hinted at in the *mentek* report. In so doing he undermined the exemplary value of Kobus's findings. Van der Elst accused Kobus of uncritically using data from one source, a planter who had no scientific credentials to speak of. Van der Elst had checked this data and found it to be at best selectively drawn to highlight the best case for planters, and at worst an outright misrepresentation of the facts.⁷⁴ Van der Elst scathingly attacked the work of this planter, and implicitly the reliability of unverified reports from sugar planters in general:

It is most wondrous of all that the administrator of a sugar factory would know his own planting area so little that he ... would call the advantages of cane agriculture so absolutely visible, and even give the impression that the yield was better the longer there had been cane agriculture, while – so it seems – the influence of cane on rice yield in that area absolutely doesn't exist.⁷⁵

Van der Elst saved most of his scorn for Kobus however:

On the basis of this single test ... Kobus found himself justified to triumphantly declare that further tests were unnecessary. Had he done this experiment himself,

it might have been a better basis on which to build conclusion ... he then made an attempt ... to use the circumstances in Sidhoarjo as evidence to stand in for Madiun. The situations in these areas are entirely different.⁷⁶

Van der Elst rejected Kobus's experiments, not because they were poorly done, but because they did not demonstrate their applicability anywhere but in the region in which they were done. After destroying the credibility of Kobus, van der Elst reinterpreted Kobus's data in light of his own empirical understanding of the region. Much as he had found in the *mentek* report, van der Elst judged that the rice paddies in most parts of Madiun did indeed demonstrate some nitrogen exhaustion, and that irrigation factors were the most critical for determining the positive or negative outcome of the sugar/rice rotation. For good measure, his new calculations demonstrated that sulphate of ammonia when used as a sole fertiliser could indeed produce soil exhaustion, a conclusion made somewhat less than momentous by the fact that many sugar planters had by this time stopped that practice on their own, using a new mix of fertilisers that included superphosphates.⁷⁷

CONCLUSION: THE DEPARTMENT OF AGRICULTURE, AND THE IMPORTANCE OF PLACE

Van der Elst based his authority to speak on his intimate knowledge of place, and the growing understanding of the variations between places that he obtained for the Department of Agriculture. Van der Elst's research in Madiun became the definitive study of *mentek* for many years, and his complicated picture of the relationship between rice, water, and sugar put an end to the scientific controversy.⁷⁸ Van der Elst continued to refine his understanding of the relationship between irrigation and rice production in a later set of experiments which he coordinated for the Department of Agriculture.⁷⁹ Van der Elst's appreciation for the variations in soil and water even within fairly small regions made him suspicious of trying to apply results obtained from local experiments on a larger scale, because, by his own argument, it was never clear how well the results might apply outside a small area.⁸⁰ His knowledge of subtle differences from place to place kept his proposals for improvements small-scale and sensitive to local conditions.

In the controversy over the ecological relationship between rice and sugar, empirical knowledge that could be shown to be both broad (i.e., significantly covering an area of study) and deep proved critical to resolving the debate. Van der Elst's comprehensive knowledge of the rice/sugar villages of Madiun allowed him to illuminate the controversial exemplary cases of others in the wider context of ecological variation in the region, strengthening the legitimacy and authority of his interpretations. While sugar planters might have been able to claim a similar depth of knowledge about the land they leased, they were unable

or unwilling to match the Department of Agriculture's scope of knowledge, that is, the wide-ranging and comparative understanding of all the places on Java. It was the scope of their studies that allowed the Department of Agriculture to escape the accusations of interest that plagued the exemplary cases of others, and to cement its authority to speak for, and create knowledge pertaining to, indigenous agriculture.

Van der Elst's use of empirical knowledge and attention to local variability is representative of a larger trend in the Department of Agriculture's approach to 'Native development', especially when it came to efforts by the extension service to improve rice yields.⁸¹ As the extension service increased the number of demonstration and test fields across the island of Java in the 1910s, they gained an appreciation for the diversity of social and ecological conditions that contributed to rice yield, and sought to find rice varieties and techniques that increased production by suiting local conditions and tastes.⁸² The Department also ran long-term (i.e., 5–10 year), detailed investigations into the social, economic, and technical organisation of agricultural production of villages across Java.⁸³ From the sugar/rice controversy it is possible to understand the ways that such an approach could help the Department maintain its position as the central authority to speak about indigenous farming, even when such issues might also affect the powerful groups of European investors and plantation operators.

In terms of the cultivated environment of Java, the Dutch approach to knowledge production and agricultural improvement is as notable for what it did not produce as for what it did.⁸⁴ The localised approach meant that there were few wholesale dramatic transformations of the cultivated environment, as the Department of Agriculture advocated for regionally-specific, and often small-scale change. The changes did nevertheless have important implications for the cultivated environment across the island. The best example of this is the role that the Department played in introducing a wider variety of dry-season food crops to indigenous farmers.⁸⁵ Changing crop rotations and adding new dry season crops was not only meant to improve the food supply, but also to maintain or improve soil fertility in regions with poor irrigation. The Department encouraged indigenous farmers to grow crops like cassava and soybeans as an alternative to a dry-season rice crop, a practice that depleted soils dramatically where irrigation was poor. Before making such recommendations, however, the Department typically investigated the environmental and social relations of production. The result was a broadening of dry season crops across Java that may have had a more notable effect on the Javanese diet than any increase in rice production.⁸⁶ Such changes, however, rarely changed the overall character of farming in a region. In an area where land was rotated with sugar, they did not seek to remove sugar planting, but to find crops like soybeans or green fertilisers that would help replenish the soil. Where peasants grew rice in much

the way that had been practised for centuries, the Department might try to introduce new crops to rotate with rice, encourage new rice varieties or change some aspect of rice cultivation to make it more productive, but they did not try to remove rice agriculture altogether, nor completely transform its practice. In all respects, the Department refused to play a revolutionary role. A superficial look at cultivation on Java might suggest that no changes had taken place at all, even though this was not the case.

The subtlety of the Dutch approach, and its lack of dramatic environmental transformation contrasts significantly with other stories of the colonial politics of agricultural and environmental change. In one part of James Scott's illuminating study of 'authoritarian high modernism,' he examines a mindset towards technological improvement of agriculture that de-emphasised the significance of local difference and local practices in agriculture, in order to create a less complex, more easily managed reality in its place.⁸⁷ In such cases, scientific theories, or technological assumptions took precedence, at least among high-level officials, over the detailed, empirical understanding of the places and people they wished to transform. Such cases can indeed be found in colonial history,⁸⁸ and Scott's insights are important for understanding colonial projects of transformation.

Not all colonial improvement projects, however, chose the path of simplification, as this essay has shown. How do particular scientific approaches, whether theoretical work that simplifies or empirical studies that complicate, gain enough authority to become the basis of transformation? In the Netherlands East Indies, scientists and officials had to work to establish their credibility to speak to problems of indigenous agriculture and to define the ecological realities of the colony. Unlike the cases that Scott describes, the authority of the colonial government was not sufficient in itself to grant credibility to the Department of Agriculture with the wider community of the Netherlands East Indies. Detailed, empirical knowledge of entire regions, not simplifying scientific assumptions, became the vital tool with which the state established its authority and credibility as a producer of scientific knowledge. This approach allowed them to defend their knowledge as the privileged basis for policies of colonial development in the face of accusations of bias. In the Indies, a more complicated view of the colony could serve as vital a political purpose as a more simplified view. At the same time, scientists put this hard won empirical knowledge to use in a restrained, if not necessarily modest way, by rejecting the possibility of wholesale transformation and preferring instead a process of change more in tune with their understanding of the variability of local conditions.

NOTES

¹ For place names I use the current standard Indonesian spelling. Names of persons and institutions follow the spelling of the period.

² Report quoted in Z. Kamerling, 'Achteruitgang in vruchtbaarheid der voor de rietcultuur gebruikte gronden' (Decline in Fertility on Lands Used for Cane Culture), *Soerabaiasch Handelsblad*, 16 February 1905.

³ Het Algemeen Syndicaat van Suikerfabrikanten.

⁴ Z. Kamerling, 'Achteruitgang in vruchtbaarheid der voor de rietcultuur gebruikte gronden' The Resident's description of the problem, as well as his solution, match Kamerling's so closely, it seems reasonable to assume that Kamerling was his main source of information.

⁵ Ibid. Kobus was also editor of the *Archief voor de Java-suikerindustrie*, a journal of scientific and technical reports on the sugar industry.

⁶ Het Proefstation Oost-Java

⁷ Among the most prominent of the critics of the practices of the sugar industry was H.H. van Kol, a member of the lower house of the Dutch parliament, the Tweede Kamer. See for example his criticisms of the sugar industry voiced in the Tweede Kamer. (Reprinted in the *Archief voor de Java-suikerindustrie*, 1907).

⁸ On the mission of the Department of Agriculture, see *Regeerings-almanak voor Nederlandsch-Indie*, 1905.

⁹ For more on the Cultivation System see Cornelis Fasseur, *The Politics of Colonial Exploitation: Java, the Dutch, and the Cultivation System* (Ithaca: Southeast Asia Program, Cornell University, 1992). For the case of sugar production see R.E. Elson, *Javanese Peasants and the Colonial Sugar Industry: Impact and Change in an East Java Residency, 1830–1940* (Oxford: Oxford University Press, 1984).

¹⁰ For more on the Sugar Law of 1870 see J.S. Furnivall, *Netherlands Indië* (Cambridge: Cambridge University Press, 1944), p. 165.

¹¹ When I use the terms European, Chinese and Native in this respect, I am referring to the legal category used in the colony at the time, and my use of the capitalisation is meant to be a reminder that these were constructed categories, not natural distinctions.

¹² Furnivall, *Netherlands Indië*, pp. 178–9. Also see Elson, *Javanese Peasants and the Colonial Sugar Industry*, pp. 127–8.

¹³ Furnivall, *Netherlands Indië*, p. 180.

¹⁴ Ibid., pp. 178–80. The Agrarian Law also regulated which land could be considered Native land, and which 'waste' land that would then fall under state control.

¹⁵ Clifford Geertz, *Agricultural Involution: The Processes of Ecological Change in Indonesia*, pp. 87–9. Although frequently (and fairly) criticised for its analysis of labour relations in the sugar lands, *Agricultural Involution* is still a good introduction to the intricacies of the sugar leasing practices on Java. See also Elson, *Javanese Peasants and the Colonial Sugar Industry*. Sugar manufacturers often kept different portions of the land at different stages in the rotation so that there would be a yearly sugar crop.

¹⁶ J.D. Kobus, 'Achteruitgang in vruchtbaarheid der voor de rietcultuur gebruikte gronden?' *Archief voor de Java-suikerindustrie*, vol. xiii (1905): 282–3. This was confirmed with some qualifications in P. van der Elst, 'De Padioogstmislukking in de Residentie Madi-

oen in 1910: Een onderzoek naar de oorzaken der Omo Mentek en naar Nawerking van Suikerriet op Padi in die Residentie', *Mededeelingen van het Proefstation voor Rijst c.a.* (Batavia: G. Kolff, 1912), p. 44.

¹⁷ See for example H.C.H. de Bie, *De Landbouw der Inlandsche Bevolking op Java* (Batavia: G. Kolff & co., 1902) for a scientific study that gives detailed attention to irrigation practices of various kinds of indigenous rice agriculture.

¹⁸ For examples from the time see: 'Irrigatiegrievten tegen de suikercultuur', no author given, *Archief voor de Java-suikerindustrie*, Bijblad, vol. xvi (1908): 613–20; D. van Hinloopen Labberton, 'Invloed van de suikerfabriek op hare omgeving', *Archief voor de Java-suikerindustrie*, Bijblad, vol. xvi (1908): 796–7. Others argued that only careful study of agricultural conditions could guarantee such benefit, see for example: J. Homan van der Heide, *Beschouwingen aangaande de Volkswelvaart en het Irrigatiewezen op Java* (Batavia: G. Kolff, 1899); J. Nuhout van der Veen, *Irrigatie en Landbouw op Java* ('s Gravenhage: G.A. Kottman, 1907). For more recent studies of irrigation in Indonesia see: Wim Ravesteijn, *De Zegenrijke Heeren der Wateren: Irrigatie en Staat op Java, 1832–1942* (Delft: Delft University Press, 1997); Petrus van der Eng, *Agricultural Growth in Indonesia since 1880* (Groningen: Universiteitsdrukkerij, Rijksuniversiteit Groningen, 1993), especially pp. 57–60. Van der Eng disputes the contention that irrigation works on Java predominantly benefited sugar planters. For more on the problems of irrigation systems for rice farmers see Anne Booth, 'Irrigation in Indonesia, pt. I', *Bulletin of Indonesian Economic Studies*, vol. 13, no. 1 (March 1977).

¹⁹ A survey of the *Archief voor de Java-suikerindustrie*, the journal for scientific sugar research in the Indies show no studies of the effects of sugar growing on subsequent rice or secondary crops before 1910. Later studies of the relationship cite no previous studies. There are one or two studies of the effects of sulphate of ammonia fertiliser on rice, including Kreisler, 'Verslag omtrent in den Westmoesson van 1898/1899 genomen bemestingsproeven met zwavelzure ammonia op met padi beplante sawahs in de Controle Afdeling Kota Pasoeroeran en Grati', *Archief voor de Java-suikerindustrie*, 1899. One exchange of articles by H. Prinsen Geerligts ('Iets over de bemesting van het suikerriet', *Archief voor de Java-suikerindustrie*, vol I: 161) and C.J. van Lookeren Campagne ('Een bemestingskwestie', *Archief voor de Java-suikerindustrie*, vol 1: 397) studied the effect of irrigation water used during rice cultivation for the subsequent sugar crop.

²⁰ For more on the problems described in this paragraph, see Elson, *Javanese Peasants and the Colonial Sugar Industry*.

²¹ Margeret Leidelmeijer, *Van Suikermolen tot Grootbedrijf: Technische Vernieuwing in de Java-suikerindustrie in de Negentiende Eeuw* (Amsterdam: NEHA, 1997).

²² For a description of day–night regulations and their problems written during the colonial era, see 'Het Wadoek Stelsel' (no author given), *Koloniale Studiën*, 1920: 65–91.

²³ For discussions of this subject from the time see: D. van Hinloopen Labberton 'Invloed van de suikerfabriek op hare omgeving', *Archief voor de Java-suikerindustrie*, Bijblad, vol. xvi (1908): 749–802; E. H. s' Jacob, *De Economische Betekenis van de Suikerindustrie op Java* (Batavia: G. Kolff, 1903). For opposing views, arguments in the Tweede Kamer are a good resource. See, for example, the debate from the the 1909 colonial budget talks, reprinted as 'Stemmen in de Tweede Kamer over de suikerindustrie op Java', *Archief voor de Java-suikerindustrie*, Bijblad vol. xvi (1908): 1051–72.

²⁴ R.E. Elson, *Javanese Peasants and the Colonial Sugar Industry*; Loekman Soetrisno, *The Sugar Industry and Rural Development: The Impact of Cane Cultivation for Export on Rural Java, 1830–1934* (Dissertation, Cornell University, 1980).

²⁵ Speech by Queen Wilhelmina cited in P. Creutzberg, *Het Economische Beleid in Nederlandsch-Indië* (Groningen: H.D. Tjeenk Willink, 1972), vol. 1, p. 173, see footnote 1. For a good overview of the Ethical policies see Merle Ricklefs, *A History of Modern Indonesia since c.1300* (Stanford: Stanford University Press, 1993). Among the most famous of commentaries on the problems of the colonial system for indigenous people, and the obligations of the colonial government is C. Th. van Deventer, 'Een Eereschuld', *De Gids*, vol. 63 (1899). P. Brooshoof applied the term 'Ethical' to these policies retrospectively in his short work, *De Ethische Koers in Koloniale Politiek* (Amsterdam: DeBussy, 1901).

²⁶ The Outer Possessions included all the other islands in the archipelago. Of particular interest for Javanese emigration were Borneo, Sumatra and Sulawesi.

²⁷ Z. Kamerling, 'Achteruitgang in vruchtbaarheid der voor de rietcultuur gebruikte gronden' (Decline in Fertility on Soil Used for Cane Culture), *Soerabaiasch Handelsblad*, 16 Feb. 1905 – 31 Mar. 1905.

²⁸ For details on Kamerling's background see *Onderzoek Naar de Mindere Welvaart der Inlandsche Bevolking op Java en Madoera*, Batavia, vol. 5a (1907): 200. For references to his earlier work see Kamerling, 'Achteruitgang in vruchtbaarheid', 21 March 1905. The introduction of chemical fertilisers to Java came primarily through the agency of sugar producers in the late 1800s. The use of sulphate of ammonia was discussed in the sugar industry publications, especially in *Archief voor de Java-suikerindustrie*. In the Netherlands, the introduction of chemical fertilisers in the mid- to late-nineteenth century had produced dramatic yield improvements. See Jan Bieleman, *Geschiedenis van de Landbouw in Nederland, 1500–1950: Veranderingen en Verscheidenheid* (Amsterdam: Meppel, 1992).

²⁹ Kamerling, 'Achteruitgang in vruchtbaarheid', 16 Feb. 1905.

³⁰ *Ibid.*, 21 March 1905

³¹ I am using the term ecological here to refer to the effects of the sugar/rice rotation on soil, water, and plants, to distinguish this part of the debate from the broader discussions of land rent and labour usage that focused on the relationship between planters and farmers.

³² The term 'black box' is used frequently in the history of technology and science and technology studies to refer to the status of technologies whose inner workings are not considered important to wider society. Opening a black box means taking the inner workings of a technology to public scrutiny.

³³ Kamerling, 'Achteruitgang in vruchtbaarheid der voor de rietcultuur gebruikte gronden', 16 Feb. 1905.

³⁴ *Ibid.*

³⁵ *Ibid.*, 21 Feb. 1905. He cites studies by Lawes and Gilbert from Rothamstead, England as reported by the USDA in 1895.

³⁶ *Ibid.*, 16 March 1905. He cites F.A.F.C. Went, 'Waarnemingen and Opmerkingen omtrent de rietsuikerindustrie in West Indië' (no publication info.)

³⁷ *Ibid.*, 8 March 1905. He cites studies by van Lookeren Campagne and Prinsen Geerlig.

³⁸ Ibid.

³⁹ Ibid., 16. Feb. 1905.

⁴⁰ Ibid. Kamerling quotes Kobus's memorandum addressed to the Resident of Madiun in the first instalment of the series of articles.

⁴¹ Ibid.

⁴² Ibid., p. 321.

⁴³ Suzanne Moon, *Constructing 'Native Development': Technological Change and the Politics of Colonization in the Netherlands East Indies, 1905–1930* (dissertation, Cornell University, 2000).

⁴⁴ E.H. s'Jacob, *De Economische Betekenis van de Suikerindustrie op Java* (Batavia, 1903), pp. 1–26.

⁴⁵ *Onderzoek naar de Mindere Welvaart*, vol. 5a (Batavia, 1907), pp. 196–201.

⁴⁶ Article quoted at length in the *Archief voor de Java-suikerindustrie, Bijblad*, vol xvi (1908): 1040–2, from *De Indische Gids*, Nov. 1908.

⁴⁷ Ibid., p. 1042.

⁴⁸ 'Stemmen in de Tweede Kamer over de suikerindustrie op Java', *Archief voor de Java-suikerindustrie, Bijblad*, vol xvi (1908): 1037–40.

⁴⁹ J.D. Kobus, 'Achteruitgang in vruchtbaarheid der voor de rietcultuur gebruikte gronden?' *Archief voor de Java-suikerindustrie*, vol. xiii (1905): 281–93.

⁵⁰ Ibid., p. 283.

⁵¹ Ibid.

⁵² On replication in science, see H.M. Collins, *Changing Order: Replication and Induction in Scientific Practice* (Chicago, 1985); Bruno Latour and Steve Woolgar, *Laboratory Life: The Construction of Scientific Facts* (Princeton: Princeton University Press, 1979).

⁵³ On the importance of place in agricultural field experiments see Christopher R. Henke, 'Making a Place for Science: The Field Trial', *Social Studies of Science*, vol. 30, no. 4 (August, 2000).

⁵⁴ J.D. Kobus, 'Achteruitgang in vruchtbaarheid der voor de rietcultuur gebruikte gronden?', p. 284.

⁵⁵ Ibid.

⁵⁶ Ibid., p. 285.

⁵⁷ Ibid., p. 282. The sugar planter reported a high yield of 70 piculs/hectare as compared to around 20 piculs on the poorer ground.

⁵⁸ Ibid., pp. 282–3.

⁵⁹ Ibid., p. 293.

⁶⁰ E.H. s'Jacob, 'Problemen van de Dessa', discussion, p. 337.

⁶¹ Ibid., p. 338.

⁶² H.J.W. van Lawick, 'Suikercultuur en Inlandsche Landbouw', *Archief voor de Java-suikerindustrie, Bijblad*, vol. xv (1907): 990–1006.

⁶³ Ibid., p. 993.

⁶⁴ J.A. van Haastert, 'Verslag Omtrent de Resultaten der Bemestingsproeven in den Aanplant van Oogstjaar 1905/1906', *Archief voor de Java-suikerindustrie*, vol xvi (1908); J.D. Kobus, J.A. van Haastert. 'Padiproeven', *Archief voor de Java Suikerindustrie*, vol.

xvi (1908): 571–93. It is unclear how the Department of Agriculture or Melchior Treub responded to these periodic calls for their involvement. The department did not organise experiments, nor did they report on the problem in their yearbooks from 1905–1910. They may not have considered it a top priority, or they may have had trouble organising such work when they were beset with other organisational and staffing difficulties.

⁶⁵ Kobus, van Haastert, 'Padiproeven', p. 578.

⁶⁶ Early works on *omomentek* include J. van Breda de Haan, 'Omo Mentek, een aaltjesziekte der padi', *Mededeelingen uit 's Land's Plantentuin*, vol. LIII, Batavia, 1902. Van Breda de Haan hypothesised that the disease was caused by an insect. In the 1960s the disease was determined to have been caused by a virus. H. Toxopeus, 'Landbouwkundig onderzoek: het Algemeen Proefstation voor de Landbouw ALP en resultaten in de praktijk', *Landbouwwonderwijs, -voorlichting, en -onderzoek voor de kleine boer op Java, 1900–1940*. NEHA-Jaarboek, NEHA, Amsterdam: 1999.

⁶⁷ P. van der Elst, 'De Padioogstmislukking in de Residentie Madioen in 1910: Een onderzoek naar de oorzaken der Omo Mentek en naar Nawerking van Suikerriet op Padi in die Residentie', *Mededeelingen van het Proefstation voor Rijst c.a.* (Batavia, 1912).

⁶⁸ The chapter entitled 'Fertility, Irrigation, and Crop Rotation' is more than a quarter of the entire ten chapter text.

⁶⁹ See discussion in van der Elst, 'De Padioogstmislukking in de Residentie Madioen in 1910', pp. 26–50.

⁷⁰ *Ibid.*, pp. i–iv.

⁷¹ *Ibid.* See analysis, pp. 40–50 and footnote about Kobus on p. 45.

⁷² This is the new name for the *Archief voor de Java-suikerindustrie*.

⁷³ P. van der Elst, 'Over de Nawerking van Suikerriet op Padi in de Residentie Madioen', *Archief voor de Suiker-Industrie in Nederlandsch-Indië*, vol. axe, no. 1 (1913).

⁷⁴ *Ibid.*, pp. 560–70. In order to estimate the tax for rice producers, the government did test cuttings of rice fields across the island, to determine the yields for that year.

⁷⁵ *Ibid.*, pp. 563–4.

⁷⁶ *Ibid.*, p. 559.

⁷⁷ *Ibid.*, p. 575.

⁷⁸ A survey of literature from both the Department of Agriculture and the Sugar Experiment Station finds no new articles on the sugar/rice relationship questioning van der Elst's results.

⁷⁹ P. van der Elst, 'Bevloeingsproeven bij Padi-cultuur: Opzet der Proeven', *Mededeelingen van het Proefstation voor Rijst c.a.*, no. 2 (Batavia: G. Kolff, 1916).

⁸⁰ See comments on this in P. van der Elst, 'Bevloeingsproeven bij Padi-cultuur', p. 12.

⁸¹ Gé H.A. Prince, 'Landbouwvoorlichting en onderwijs als onderdelen van de koloniale welvaartspolitiek', *Landbouwwonderwijs, -voorlichting, en -onderzoek voor de kleine boer op Java, 1900–1940*. NEHA-Jaarboek, NEHA, Amsterdam: 1999. Suzanne Moon, 'Constructing 'Native Development''.

⁸² Suzanne Moon, 'Constructing 'Native Development'', pp. 50–69.

⁸³ For example see Egbert de Vries, *Landbouw en Welvaart in het Regentschap Pasoeroean: Bijdrage tot de Kennis van de Sociale Economie van Java* (dissertation, Wageningen, 1931).

⁸⁴ I am limiting my conclusions to the effects on agriculture. For a telling study of the Dutch approach to forest management that comes to different conclusions, see Nancy Peluso, *Rich Forests, Poor People : Resource Control and Resistance in Java* (Berkeley: University of California Press, 1992).

⁸⁵ Peter Boomgaard and J.L. van Zanden (eds), *Changing Economy in Indonesia: A Selection of Statistical Source Material from the Early 19th Century up to 1940*, vol. 10, 'Food Crops and Arable Lands, Java 1815–1942' (Amsterdam: Royal Tropical Institute, 1990).

⁸⁶ *Ibid.*

⁸⁷ James Scott, *Seeing Like a State: Why Some Schemes to Improve the Human Condition Have Failed* (New Haven: Yale University Press, 1998).

⁸⁸ In addition to the case studies in *Seeing Like a State*, see also Chris Conte, 'Colonial Science and Ecological Change: Tanzania's Mlalo Basin, 1888–1946,' *Environmental History*, vol. 4, no. 2 (April 1999): 220–44; Christophe Bonneuil, 'Development as Experiment: Science and State Building in Late Colonial and Post-colonial Africa, 1930–1970', *Osiris*, vol. 15 (2001): 258–81.