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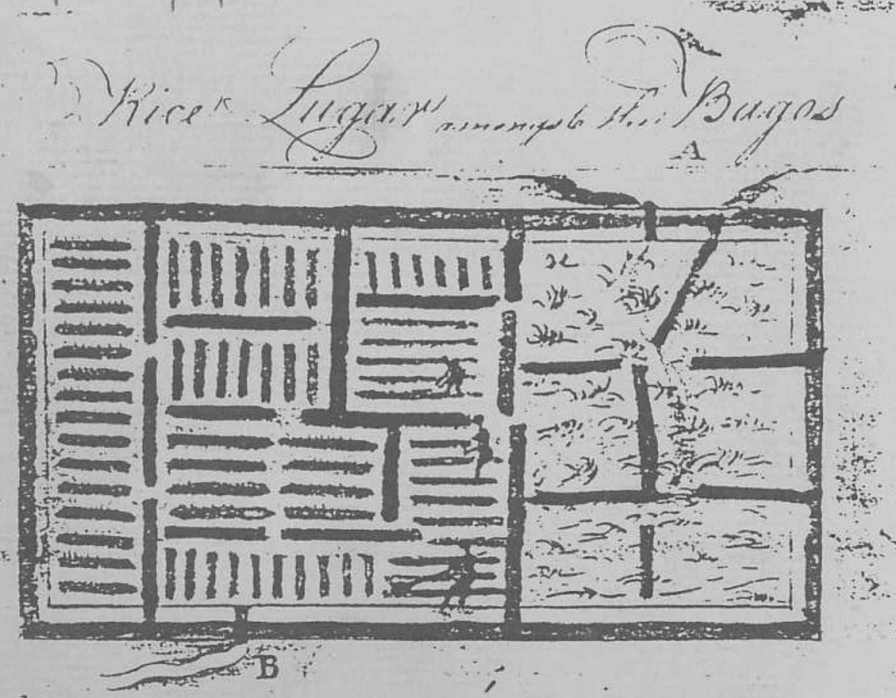

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Technology and Culture

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EDITOR'S NOTE

ARTICLES

MUSEUMS IN BRITAIN: A TRAVELLER'S INTRODUCTION

REVIEW ESSAY

BOOK REVIEWS

for the last elusive typographical error. Some people with such capacity for detail work come wrapped pretty tightly. *Technology and Culture* has been blessed over these years that Joan's graciousness and sense of humor run as deep as her discipline. Together Bob and Joan have set a high standard, one that we will do our best to maintain.

One final remark. For a variety of reasons, most of which have to do with the referee and editing process, *T&C* rarely publishes a theme issue. More commonly, we publish the next set of manuscripts in the queue, with the result that most *T&C* issues do not show much thematic coherence. Overviews that tell us something about larger research trends require longer time frames. Then too, *T&C*'s readers represent a federation of sometimes loosely related scholarly interests. *Technology and Culture* depends on its ability to entice readers to explore articles outside their primary areas of interest. The more that happens, the more effectively *T&C* contributes to SHOT's communal life.

To help these processes along, I have decided to initiate two modest helps for the readership. First, immediately after the table of contents you will find a summary of the issue's articles. These sketches will also be accessible before an issue is mailed through *T&C*'s World Wide Web site. Second, in the October issue each year, I will take two or three pages to interpret the year's articles from a historiographical perspective. I hope both innovations will contribute to the welcoming and vital community that has grown up around the nucleus of *Technology and Culture* since Mel began work in 1959.

JOHN M. STAUDENMAIER, S.J.

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Landscapes of Technology Transfer: Rice Cultivation and African Continuities

JUDITH CARNEY

By the mid-1700s a distinct cultivation system, based on rice, rimmed the Atlantic basin. The eastern locus of rice cultivation extended inland from West Africa's upper Guinea coast. To the west the system flourished in the southeastern United States, principally along the coastal plain of South Carolina and Georgia (fig. 1). On both sides of the Atlantic, rice growing depended on African labor. West African farmers planted rice as a subsistence crop on smallholdings, with surpluses occasionally marketed, while the southeastern United States depended on a plantation system and West African slaves to produce a crop destined for international markets.

While rice cultivation continues in West Africa today, its demise in South Carolina and Georgia swiftly followed the abolition of slavery. The year 1860 marked the apogee of the antebellum rice economy. Total U.S. production reached 187.2 million pounds, with South Carolina accounting for 63.6 percent of the total and Georgia an additional 28 percent.[1] Abolition doomed this rice plantation system by liberating some 125,000 slaves who grew rice along nearly 100,000 acres of coastal plain, the property of about 550 planters.[2]

DR. CARNEY is associate professor in the Department of Geography at the University of California, Los Angeles. She thanks Peter Coclanis, David Gamble, Paul Richards, the *Technology and Culture* referees, and the editor for their critical comments, as well as Chase Langford for his assistance with the graphics.

[1] *Agriculture of the U.S., United States Census Office 1860*, 8th census (Washington D.C., 1864).

[2] Douglas C. Wilms, "The Development of Rice Culture in 18th Century Georgia," *Southeastern Geographer* 12 (1972): 45–57; Julia Floyd Smith, *Slavery and Plantation Growth in Antebellum Florida, 1821–1860* (Gainesville, Fla., 1973), and *Slavery and Rice Culture in Low Country Georgia, 1750–1860* (Knoxville, Tenn., 1985); Pat Morgan, "A Study of Tide Lands and Impoundments within a Three River Delta System—the South Edisto, Ashepoo, and Cumbahee Rivers of South Carolina" (M.A. thesis, University of Georgia, 1974); James Clifton, *Life and Labor on Argyle Island* (Savannah, Ga., 1978), pp. viii–ix, and "The Rice Industry in Colonial America," *Agricultural History* 55 (1981): 266–83; Charles A. Gresham and Donal D. Hook, "Rice Fields of South Carolina: A Resource Inventory and Management Policy Evaluation," *Coastal Zone Management Journal* 9 (1982): 183–203.

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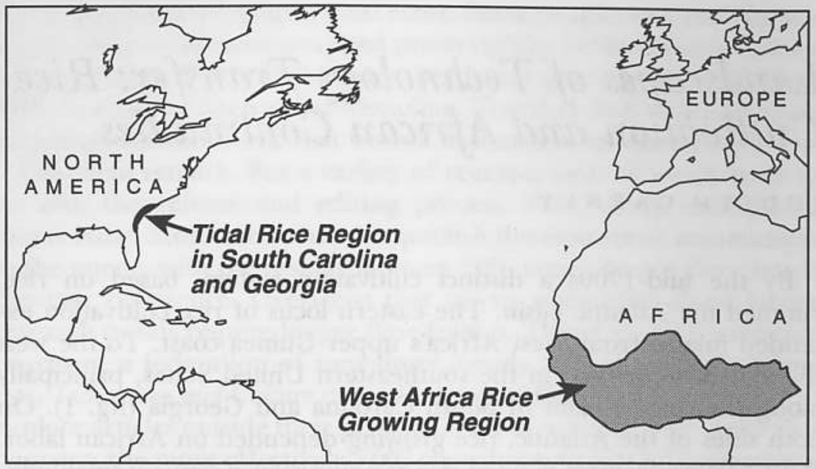

FIG. 1.—Rice cultivation along the Atlantic basin, 1760–1860. (All drawings by Chase Langford.)

The South's most lucrative plantation economy continued to inspire nostalgia well into the 20th century, when the crop and the princely fortunes it delivered remained no more than a vestige of the coastal landscape. Numerous commentaries documented the lifeways of the planters, their achievements, as well as their ingenuity in shaping a profitable landscape from malarial swamps.[3] These accounts never presented African slaves as having contributed anything but their unskilled labor. The 1970s witnessed a critical shift in perspective, as historians Converse Clowse and Peter Wood drew attention to the skills of slaves in the evolution of the South Carolina economy. Clowse, writing in 1971, revealed the importance of skilled African labor in ranching and forest extractive activities during the early colonial period. Wood's careful examination of the role of slaves in the Carolina rice plantation system during the same period, published in 1974, challenged the prevailing planter-biased rendition of the rice story. His scholarship recast the prevalent view of slaves as mere field hands and showed that they contributed agronomic expertise as well as skilled labor to the emergent plantation economy. Wood's evidence

[3] Ulrich B. Phillips, *American Negro Slavery* (New York, 1918); A. S. Salley, *The Introduction of Rice Culture into South Carolina* (Columbia, S.C., 1919); Ralph Betts Flanders, *Plantation Slavery in Georgia* (Chapel Hill, N.C., 1933); David Doar, *Rice and Rice Planting in the South Carolina Low Country* (1936; reprint, Charleston, S.C., 1970); Alice Huger Smith, *A Carolina Plantation of the Fifties* (New York, 1936); Norman Hawley, "The Old Plantations In and Around the Santee Experimental Forest," *Agricultural History* 23 (1949): 86–91; Duncan Heyward, *Seed from Madagascar* (Chapel Hill, N.C., 1937).

rested on the presence of slaves in South Carolina from the onset of settlement in 1670, early accounts suggesting that slaves produced their own subsistence crops, and the contrast between a lack of prior rice farming knowledge among the English and the French Huguenot planters and the knowledge and skill of their African slave workforce.[4] Daniel Littlefield later built on Wood's pathbreaking thesis by discussing the antiquity of African rice farming practices and by revealing that more than 40 percent of South Carolina's slaves during the colonial period originated in West Africa's rice cultivation zone.[5]

While this scholarship has resulted in a revised view of the rice plantation economy as one of both European and African cultures, the agency of African slaves in its evolution is still debated. Current formulations question whether planters recruited slaves from West Africa's rice coast to help them develop a crop whose potential they discovered independently or whether African-born slaves initiated rice planting in South Carolina by teaching planters to grow a preferred food crop. The absence of archival materials that would document a tutorial role for African slaves is not surprising given the paucity of records available in general for the early colonial period, and because racism over time institutionalized white denial of the intellectual capacity of bondsmen. An understanding of the potential role of slaves requires other forms of historical inquiry.

This article combines geographical and historical perspectives to examine the likely contributions of African-born slaves to the colonial rice economy. A spatial approach is used to focus attention on the principal microenvironments planted to rice on both sides of the Atlantic, as well as on the techniques developed for soil and water management during the colonial period. The century 1670–1770 is crucial for examining these issues since it spans the initial settlement of South Carolina by planters and slaves as well as the expansion of tidal (tidewater) rice cultivation into Georgia. By analyzing the spatial and agronomic (i.e., land-management) parameters of rice cropping systems, this cross-cultural analysis emphasizes linkages between culture, technology, and the environment that traversed the Middle Passage with slaves.

The discussion has four parts. The first section examines the geo-

[4] Converse Clowse, *Economic Beginnings in Colonial South Carolina* (Columbia, S.C., 1971); Peter Wood, *Black Majority* (New York, 1974), pp. 57–64.

[5] Daniel Littlefield, *Rice and Slaves* (Baton Rouge, La., 1981). Betty Wood, *Slavery in Colonial Georgia* (Athens, Ga., 1984), p. 103, also indicates a similar trend for Georgia, noting that three-fourths of the slaves shipped there during the critical period of tidewater rice expansion (1766–71) originated from West Africa's rice coast.

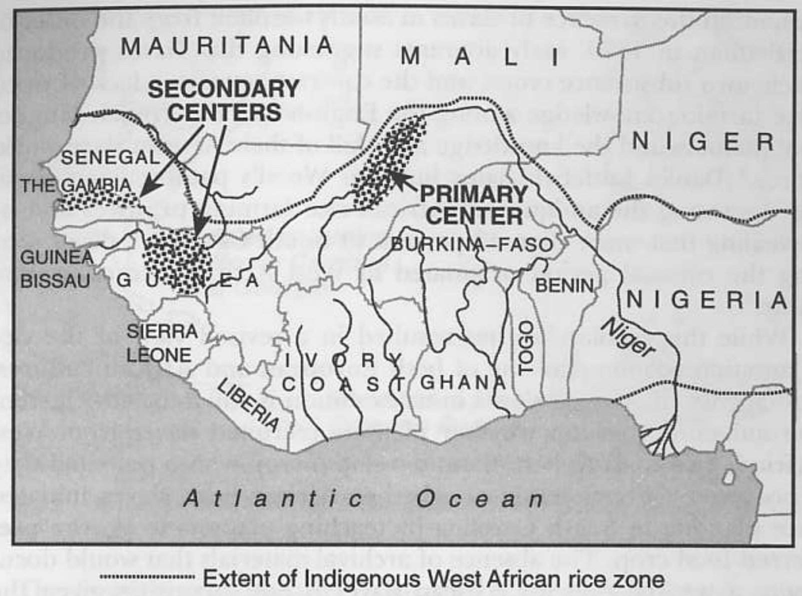

FIG. 2.—Centers of origin of African rice (*Oryza glaberrima*)

graphical and historical context for rice cultivation in the Atlantic basin, while the water- and soil-management principles underlying the three major West African rice systems are discussed in greater detail in the second part. The discussion shifts in the third section to South Carolina and Georgia, where the rice economy unfolded over time from rainfed to inland swamp production and culminated in the tidal system. The concluding section raises several questions about the issue of technology development and transfer while suggesting a lingering Eurocentric bias in historical reconstructions of the agricultural development of the Americas.

The Geographical and Historical Context of Rice Cultivation along the Atlantic Basin

Some 3,500 years ago West Africans domesticated rice (*Oryza glaberrima*), independently of the Asian cultivar (*Oryza sativa*), along the floodplain and inland delta of the upper and middle Niger River in Mali.[6] The rice-growing area of West Africa, depicted in figure 2,

[6]Roland Portères, "Primary Cradles of Agriculture in the African Continent," in *Papers in African Prehistory,* ed. J. D. Fage and R. A. Oliver (Cambridge, 1970), pp. 43–58; Jack Harlan, J. De Wet, and A. Stemler, *Origins of African Plant Domestication* (Chicago, 1976); R. Charbolin, "Rice in West Africa," in *Food Crops of the Lowland Tropics,* ed. C. L. A. Leakey and J. B. Wills (Oxford, 1977), pp. 7–25.

extends along the coast from Senegal to the Ivory Coast and into the interior through the savanna along river banks, inland swamps, and lake margins. Within this climatically and geographically diverse setting, two secondary centers of rice domestication emerged: a floodplain system located along river tributaries north and south of the Gambia River (bounded on the north by the river Sine and on the south by the river Casamance, both in Senegal); and another, rain-fed system found farther south in the forested Guinea highlands where rainfall reaches 2,000 mm per year. By the end of the 17th century rice had crossed the Atlantic basin to the United States, appearing first as a rain-fed crop in South Carolina before its diffusion along river floodplains and into Georgia from the 1750s.

Many similarities characterized rice production on both sides of the Atlantic basin. The most productive system in South Carolina developed along floodplains, as in West Africa. Precipitation in each region follows a marked seasonal pattern, with rains generally occurring during the months from May/June to September/October. Rice cultivation flourished in South Carolina and Georgia under annual precipitation averages of 1,100–1,400 mm, figures that represent the midrange of a more varied rainfall pattern influencing West African rice cultivation.[7] In the West African production zone, precipitation increases dramatically over short distances in a north-to-south direction, with much less variation occurring over greater distances from east to west. Thus, in the Gambian secondary center of domestication, semiarid (900 mm annual precipitation) conditions prevail, as in the Malian primary center, while farther south in Guinea-Bissau and Sierra Leone precipitation exceeds 1,500 mm per year.[8]

The topography of the rice-growing region on both sides of the Atlantic presents a similar visual field. The coastline is irregularly shaped and formed from alluvial deposits that also create estuarine islands. Rivers carry freshwater downstream on their way to the sea, resulting in tidal flows over the floodplain. The steeper descent from the piedmont in South Carolina and Georgia delivers freshwater tidal flows to floodplains just 10 miles from the Atlantic coast. But the less-pronounced gradient of West Africa's rice rivers means that freshwater tides meet marine water much farther upstream from the coast. Saltwater constantly menaces the downstream reaches of rivers like the Gambia, where salinity permanently affects the lower 80 km

[7]Charles Kovacik and John Winberry, *South Carolina: The Making of a Landscape* (Boulder, Colo., 1987); Timothy Silver, *A New Face on the Countryside* (New York, 1990).
[8]Judith Carney, "The Social History of Gambian Rice Production: An Analysis of Food Security Strategies" (Ph.D. diss., University of California, Berkeley, 1986).

but seasonally intrudes more than 200 km upstream.[9] The advance of saltwater in coastal estuaries, however, failed to discourage West Africans from adapting rice cultivation to this environment. Farther south of the Gambia River where rainfall exceeds 1,500 mm, rice planting occurs in an even more challenging environment—on tidal floodplains formed under marine water influence. The underlying potential acid-sulfate soils depend on water saturation to prevent them from oxidizing and developing the acidic condition that would preclude continued planting.[10] West African rice farmers avoid this problem by constructing an elaborate network of embankments, dikes, canals, and sluice gates to bar marine water while capturing rainfall for cultivation.

Rice cultivation continues throughout West Africa today under conditions similar to those that prevailed at the onset of the Atlantic slave trade. When Islamic scholars followed preexisting overland trade routes to the Malian empire in the 14th century, they arrived in the heart of West African rice domestication, where food surpluses had sustained empire formation from the 9th century.[11] Their earliest commentaries mention the crop's widespread cultivation.[12] Description of West African rice systems came later, with the arrival of European vessels along the Atlantic coast from 1453. Dependence on marine navigation brought the Portuguese into early contact with the rice cultivation systems developed along coastal estuaries (mangrove rice) and tidal rivers.[13]

[9] Ibid., p. 23; George Brooks, *Landlords and Strangers: Ecology, Society, and Trade in Western Africa, 1000–1630* (Boulder, Colo., 1993), pp. 9–13.

[10] F. R. Moorman and W. J. Veldkamp, "Land and Rice in Africa: Constraints and Potentials," in *Rice in Africa,* ed. I. Buddenhagen and J. Persely (London, 1978), pp. 29–43; West African Rice Development Association, *Types of Rice Cultivation in West Africa,* Occasional Paper no. 2 (Monrovia, Liberia, 1980); Carney, "Social History of Gambian Rice."

[11] H. A. R. Gibb, *Ibn Battuta: Travels in Asia and Africa, 1325–1354* (London, 1969); Graham Connah, *African Civilizations* (New York, 1987).

[12] Tadeusz Lewicki, *West African Food in the Middle Ages* (Cambridge, 1974).

[13] See, e.g., Paul Pélissier, *Les paysans du Sénégal: Les civilisations agraires du Cayor à la Casamance* (Saint-Yrieix, France, 1966), pp. 711–12. Pélissier quotes [A]Zurara's 1446 observation in the vicinity of the Gambia River that "they found there a river of great expanse, which they entered with their caravels . . . [Some of the men] landed . . . and following for some distance said they found the country covered with a great deal of territory sown to rice." Pélissier also quotes Eustache de la Fosse on his 1479–80 visit to the littoral rivers of southern [Casamance] Senegal and Guinea-Bissau: "We had . . . good rice and good milk. . . . I asked our captain [pilot] the origin of this good rice . . . He told me . . . they had arrived at the Ydolles Islands and found that the Blacks abounded in the goods. At their market place they had several large mounds of rice . . . and all was brought to the ships" (author's translations). See also Gomes Eannes de Azurara, *The Chronicle of the Discovery and Conquest of Guinea,* vol. 2 (London, 1899); G. R. Crone, *The Voyages of Cadamosto* (London, 1937); A. Donelha, *An Account of Sierra Leone and the Rivers of Guinea and Cape Verde* (Lisbon, 1977).

As the Atlantic slave trade gained momentum in the region over the next century, rice cultivation on the littoral drew repeated interest and comment. In 1594, long before the permanent settlement of South Carolina, André Alvares de Almada provided the first detailed description of the mangrove rice system that continues to characterize coastal estuary production south of the Gambia River. He noted the use of dikes to impound rainwater for seedling submergence and desalination, ridging to improve soil aeration, and transplanting.[14] De Almada's description leaves no doubt as to the existence of sophisticated water- and soil-management techniques from the earliest period of contact with Europeans. One 18th-century slaver captain, Sam Gamble, found this system so elaborate that he provided a diagram of the field layout in conjunction with his description of water-management techniques (fig. 3).[15]

Discussion of the upland and inland swamp cultivation systems away from coastal and riverine access routes first appeared around 1640 in a manuscript published by an Amsterdam geographer, Olfert Dapper. Relying on information supplied by Dutch merchants operating during the early 17th century in the region currently known as Sierra Leone and Liberia, Dapper described a rice farming system where cultivation occurred in distinct microenvironments along a lowland-to-upland landscape gradient which included inland swamps as well as uplands: "Those who are hard-working can cultivate three rice-fields in one summer: they sow the first rice on low ground, the second a little higher and the third . . . on the high ground, each a month after the previous one, in order not to have all the rice ripe at the same time. This is the commonest [*sic*] practice throughout the country . . . The first or early rice, sown in low and damp areas . . . the second, sown on somewhat higher ground . . . the third, sown on the high ground."[16]

[14] Valentim Fernandes, *Description de la Côte Occidentale d'Afrique* (Bissau, Guinea-Bissau, 1951); Walter Rodney, *A History of the Upper Guinea Coast, 1545–1800* (New York, 1970).

[15] For more detailed discussion of these early European commentaries on rice cultivation along the West African Atlantic coast, see Judith Carney, "From Hands to Tutors: African Expertise in the South Carolina Rice Economy," *Agricultural History* 67 (1993): 1–30.

[16] Translation and excerpt drawn from Olfert Dapper, *New Description of Africa,* by Paul Richards, in "Culture and Community Values in the Selection and Maintenance

Additional observations of these systems came later, during the mid-18th century, when Europeans financed overland expeditions for exploration, trade, and science.[17] The growing dispersal of Europeans into the West African interior during the 19th century brought more detailed commentaries on forest clearance for planting rain-fed rice and the field's subsequent rotation for cattle grazing, as well as the use of earthen reservoirs in inland swamps for water impoundment against drought.[18]

The Agronomic and Technological Basis of West African Rice Systems

Even though higher-yielding Asian rice (*O. sativa*) varieties and pump-irrigation systems now dominate throughout the West African rice zone, the production systems that predate the Atlantic slave trade persevere in the region today. Several researchers have favorably compared the diversity of the West African rice systems to those in Asia, especially noting the African crop's production under quite different rainfall patterns, soils, farming systems, and land types.[19] A recent study underscored the diversity of microenvironments and land-management practices characteristic of the African systems by identifying eighteen different environments planted in the West African rice zone.[20] This article emphasizes the main features of African production systems that potentially bear on the evolution of the rice plantation economy in South Carolina and Georgia.[21] Prioritized for

of African Rice" (paper presented at the Conference on Intellectual Property Rights and Indigenous Knowledge, Lake Tahoe, Calif., October 5–10, 1993). On Dapper, see also Adam Jones, *From Slaves to Palm Kernels* (Wiesbaden, 1983), and "Decompiling Dapper: A Preliminary Search for Evidence," *History in Africa* 17 (1990): 171–209.

[17] M. Adanson, *A Voyage to Sénégal, the Isle of Gorée and the River Gambia* (London, 1759); Francis Moore, *Travels into the Inland Parts of Africa* (London, 1738); G. Mollien, *Travels in Africa* (London, 1820); Mungo Park, *Travels into the Interior of Africa* (1799; reprint, London, 1954); Pélissier.

[18] Rodney; Thomas Winterbottom, *An Account of the Native Africans in the Neighbourhood of Sierra Leone* (London, 1803); René Caillié, *Travels through Central Africa to Timbuctoo, and across the Great Desert, to Morocco, Performed in the Years 1824–1828* (London, 1830).

[19] Pierre Viguier, *La riziculture indigène au Soudan Français* (Paris, 1939); Littlefield (n. 5 above); Paul Richards, *Indigenous Agricultural Revolution* (London, 1985), and *Coping with Hunger* (London, 1986).

[20] W. Andriesse and L. O. Fresco, "A Characterization of Rice-growing Environments in West Africa," *Agriculture, Ecosystems and Environment* 33 (1991): 377–95.

[21] The discussion is based on fieldwork by Judith Carney in Senegambia over a ten-year period, as well as on research of even longer duration in Casamance, Senegal, by Olga F. Linares and in Sierra Leone by Paul Richards; see, e.g., Olga F. Linares, "From Tidal Swamp to Inland Valley: On the Social Organization of Wet Rice Cultivation among the Diola of Senegal," *Africa* 5 (1981): 557–94, and *Power, Prayer and Production* (New York, 1992); Richards, *Indigenous Agricultural Revolution* and *Coping with Hunger*.

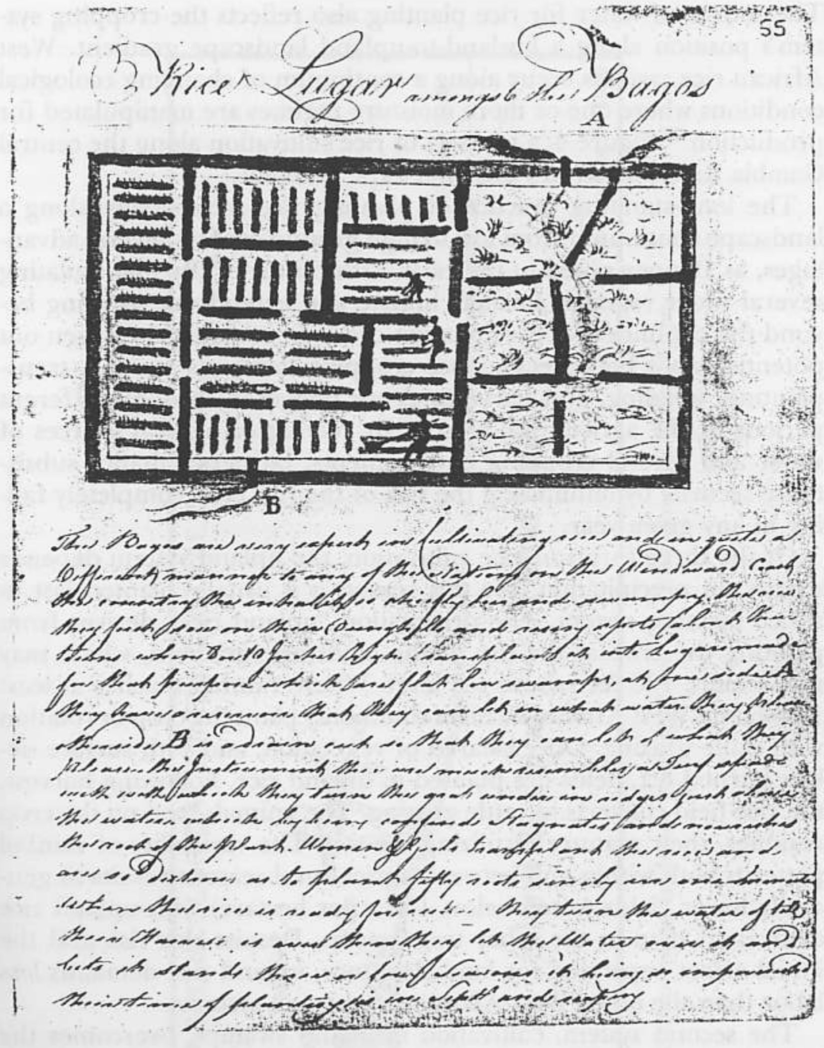

FIG. 3.—Sam Gamble's 18th-century diagram of a coastal West African rice field. (D. Littlefield, *Rice and Slaves* [Baton Rouge, La., 1981], p. 14; reprinted with permission.)

discussion are the type of water regime(s) utilized for production, the underlying agronomic techniques, and each system's relationship to yield and labor availability.

Three principal water regimes influence West African rice planting: rainfall, groundwater, and tides. The resultant rice systems are respectively known as upland, inland swamp, and tidal production.[22]

[22] F. R. Moorman and N. Van Breeman, *Rice: Soil, Water, Land* (Los Banos, Philippines, 1978).

The source of water for rice planting also reflects the cropping system's position along a lowland-to-upland landscape gradient. West African rice systems occur along a continuum of changing ecological conditions where one or more moisture regimes are manipulated for production.[23] Figure 4, a transect of rice cultivation along the central Gambia River, illustrates this landscape gradient.

The long-standing practice of planting rice sequentially along a landscape continuum from low to high ground confers several advantages, as Dapper noted in the early 17th century.[24] By manipulating several water regimes, farmers initiate and extend rice growing beyond the confines of a precipitation cycle. In so doing they even out potential labor bottlenecks, since cropping demands (sowing, transplanting, weeding, and harvesting) are staggered through different periods of the agricultural season. By relying on several sources of water and several cropping environments, farmers enhance subsistence security by minimizing the risk of the rice crop completely failing in any given year.

Of the three forms of rice cultivation, the upland system depends strictly on precipitation; for this reason it is usually planted last in a rice farming system. The designation "upland rice" derives from planting the crop at the top of the landscape gradient, which may rest a mere 100 feet above sea level. Where rainfall reaches at least 1,000 mm, West African farmers commonly plant the crop in rotation with cattle grazing. Once cleared of vegetation, and with surface debris burned off, fields are planted to upland rice. Following harvest, the rice field converts to cattle grazing. The animals feed on the crop residues, their manure fertilizing the soil. The variability of rainfall patterns both within and between agricultural seasons results in generally lower yields (often below 1 ton per hectare) with upland rice cultivation than in the other two systems. Despite this risk and the initial effort expended for land clearance, upland rice demands less labor than the other West African production systems.

The second system, cultivation in inland swamps, overcomes the precipitation constraints of upland production by capturing groundwater from artesian springs, perched water tables, or catchment runoff. "Inland swamps" actually refers to a diverse array of microenvironments which include valley bottoms, low-lying depressions, and areas of moisture-holding clay soils. The broad range of inland

[23] Richards, *Coping with Hunger;* Andriesse and Fresco, "Characterization of Rice-growing Environments."

[24] Richards, "Culture and Community Values" (n. 16 above). See also C. Fyfe, *A History of Sierra Leone* (Oxford, 1962), p. 4.

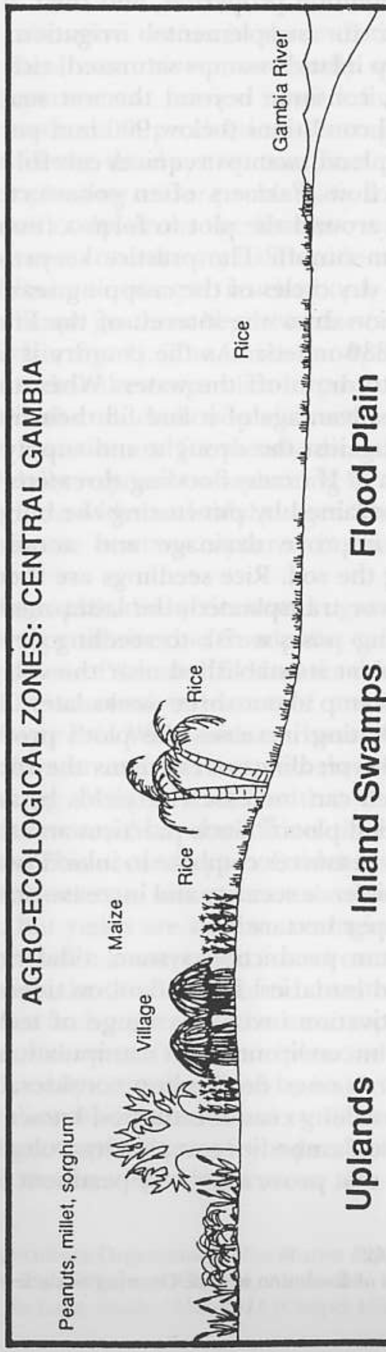

FIG. 4.—Lowland-to-upland landscape gradient of rice cultivation along the Gambia River

swamps sown to rice reflects farmers' sophisticated knowledge of soils, particularly moisture-retention properties, and their effective methods to impound water for supplemental irrigation. Where high groundwater tables keep inland swamps saturated, rice planting may begin before the rains, continue beyond the wet season, and take place under low rainfall conditions (below 900 mm per year).

But planting rice in inland swamps requires careful observance of topography and water flow. Farmers often construct bunds, small earthen embankments, around the plot to form a reservoir for capturing rainfall or stream runoff. The practice keeps soils saturated through short-duration dry cycles of the cropping season. This form of supplemental irrigation drew the interest of the French explorer René Caillié, who in 1830 noted: "As the country is flat, they take care to form channels to drain off the water. When the inundation is very great, they take advantage of it and fill their little reservoirs, that they may provide against the drought and supply the rice with the moisture it requires."[25] If excess flooding threatens the rice crop, the plot can be quickly drained by puncturing the bund.

Farmers sometimes improve drainage and aeration in inland swamp plots by ridging the soil. Rice seedlings are then either sown directly atop the ridges or transplanted, the latter method being favored when waterlogging poses a risk to seedling development. In such cases, the young plant is established near the village and transplanted to the inland swamp about three weeks later. Though more labor-intensive, transplanting increases the plot's productivity. The process of pulling up the seedlings strengthens the root system and promotes tillering, which can increase rice yields by as much as 40 percent over direct-seeded plots.[26] Such practices and the use of supplemental groundwater resources combine in inland swamp rice production to improve subsistence security and increase rice yields, which generally exceed 1 ton per hectare.

The remaining African production system, tidal rice, occurs on floodplains of rivers and estuaries. Dependent on tides to flood and/or drain the fields, cultivation involves a range of techniques from those requiring little or no environmental manipulation (planting on freshwater floodplains) to ones demanding considerable landscape modification (cultivation along coastal estuaries, known as mangrove rice). Tidal rice cultivation embodies complex hydrological and land-management principles that prove especially pertinent for examining

[25] Caillié (n. 18 above), p. 162.

[26] Francesca Bray, "Patterns of Evolution in Rice Growing Societies," *Journal of Peasant Societies* 11 (1983): 3–33.

the issue of African agency in the transfer of rice cultivation to the Americas.

Tidal rice cultivation occurs in three distinct floodplain environments: along freshwater rivers, seasonally saline rivers, and coastal estuaries with permanent marine water influence. The first two involve similar methods of production—letting river tides irrigate the rice fields—while the third system combines principles of each major rice system for planting under problematic soil and water conditions.

The riverine floodplain in the first two systems actually includes two microenvironments: the area alongside a river irrigated by diurnal tides, and its inner margin, reached only during full moon tides, where the landscape gradient begins to rise (see the landscape continuum illustrated in fig. 4). The inner floodplain's position along this gradient means that the crop relies in part on rainfall for water requirements. As the inner floodplain receives only occasional tidal flooding, rice varieties are frequently directly sown. But the floodplain flooded daily requires transplanting so that seedlings first reach sufficient height to withstand tidal surges. Both floodplain crops mature from moisture reserves captured in the alluvium during flood recession.

Similar topographic distinctions and agronomic techniques apply in the second type of riverine floodplain cultivation, which involves careful observation of salt and freshwater dynamics in order to plant areas under the seasonal influence of marine water. As rains discharge freshwater into West African rivers after the onset of the wet season, the saltwater interface retreats downstream. Rice cultivation takes place along riverine stretches that experience at least three months of freshwater (the maturation time of the fastest-growing seed varieties). This second type of tidal system requires less labor than the freshwater one, since seasonal saltwater conditions depress weed growth, but yields are similar, averaging between 1 and 2 tons per hectare, with the lower range found on the inner floodplains.[27]

Mangrove rice, the third form of tidal cultivation, takes place along coastal estuaries and represents the most sophisticated West African production environment. The principles underlying this system have not been sufficiently conceptualized by historians of rice development in South Carolina who have looked to West Africa for potential influences.[28] Their comparisons of rice production on both sides of the Atlantic basin understandably focus on the tidal freshwater system

[27] Food and Agriculture Organization, *Rice Mission Report to the Gambia* (Rome, 1983).

[28] Littlefield (n. 5 above); Joyce Chaplin, *An Anxious Pursuit: Agricultural Innovation and Modernity in the Lower South, 1730–1815* (Chapel Hill, N.C., 1993).

that sustained the lucrative antebellum economy of South Carolina and Georgia. But an emphasis on one production environment misses Dapper's 17th-century insight that rice planting occurs in distinct production environments along a landscape gradient. By separating out for analysis just one among the multiple environments that typically characterize a rice farming system, scholars only glimpse a fraction of the agronomic techniques and specialized knowledge that inform West African cultivation.

Thus, in emphasizing freshwater floodplain production, Littlefield correctly concludes that the African system involves minimal landscape manipulation.[29] However, rice production in tidal estuaries, on the other hand, demands considerable landscape modification and, sometimes, intervillage cooperation to manage the extensive water-control system.[30] One important outcome of this emphasis on the West African tidal river system in cross-cultural comparison is to leave unquestioned the assumption that Europeans provided the technological basis to the South Carolina tidewater system.[31] The case for African agency in introducing the sophisticated soil- and water-management infrastructure to South Carolina floodplains dramatically improves by detailing the mangrove rice system.

West African rice production in tidal estuaries occurs south of the Gambia River in areas of permanently saline water conditions where annual rainfall generally exceeds 1,500 mm. These are environments mantled by extensive stretches of mangroves whose aerial roots trap fertile alluvium swept over the littoral by marine tides. The organic matter deposited on these soils makes them among the most fertile of the West African rice zone, but they require considerable care to prevent oxidation and their transformation into acid-sulfate soils. By manipulating several water regimes and developing the infrastructure for its control, a highly productive rice system results.

Preparation of a tidal rice field begins with site selection and the construction of an earthen embankment parallel with the coast or riverine arm of the sea (fig. 5). Frequently more than a meter's height and width (the dimensions needed to block the entry of marine tides onto the rice field), the embankment stretches for several kilometers, sometimes threading together rice fields of different villages. A stand of mangroves often is left in place between the estuary and the embankment to reduce tidal force. The void left by soil removal for the

[29] See, for instance, Littlefield, p. 86.

[30] Pélissier (n. 13 above); Linares, "From Tidal Swamp" and *Power, Prayer and Production* (both n. 21 above).

[31] Heyward (n. 3 above); Doar (n. 3 above); Chaplin.

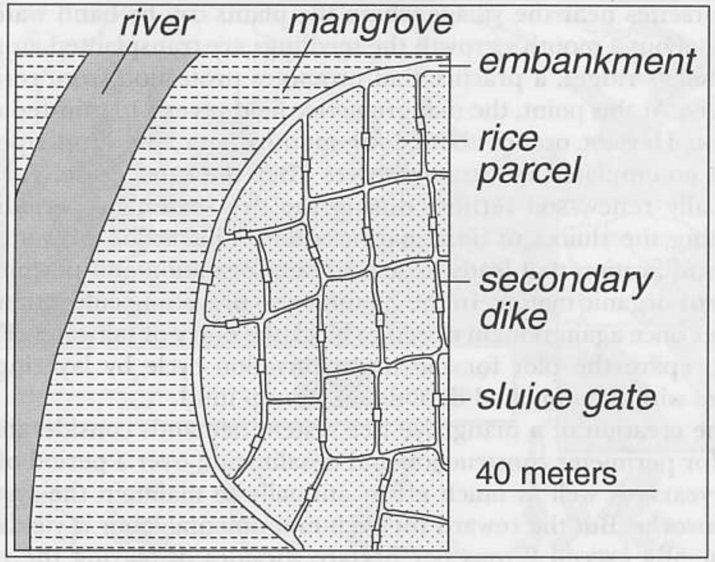

Fig. 5.—Tidal rice production system, Casamance, Senegal. (Adapted from P. Pélissier, *Les paysans du Sénégal* [Saint-Yrieix, 1966], p. 723a.)

embankment establishes the location of the principal drainage canal. A series of secondary embankments (dikes) are then formed perpendicular to the main one in order to divide the perimeter into the individual rice fields.

The mangrove rice system achieves a dual purpose with water control. It captures rainfall for irrigation while storing water for the controlled floodings that drown unwanted weeds. Sluices built into the dikes facilitate water control through the canals for either irrigation or drainage. Fitted with valves made from hollow tree trunks and plugged with palm thatch, the dike sluices drain into a more substantial one located in the principal embankment. The principal sluice is sometimes fashioned from an old canoe with a board vertically positioned like a rudder to control water flow.[32]

Once enclosed, the field is flooded by impounding rainwater and evacuating it from the field at low tide. Rainfall (and sometimes seasonal freshwater springs) leaches out the salts, which low tides help evacuate into the estuary.[33] It takes years to desalinate a mangrove field before cultivation can ensue. Each season, as farmers await the rains that will rinse away residual dry season salts, they establish rice

[32] Rodney (n. 14 above).

[33] Linares, "From Tidal Swamp," and *Power, Prayer and Production.*

in nurseries near the village where the plants can be hand watered. After about a month's growth the seedlings are transplanted atop the rice field's ridges, a practice that promotes protection from residual salinity. At this point, the mangrove rice field reverts to rain-fed cultivation. Harvest occurs about four months later, the crop ripening from accumulated moisture reserves after the rains cease. Farmers annually renew soil fertility during the dry season by periodically opening the sluices to tidal marine water. This action prevents the soil acidification that leads to acid-sulfate formation and permits deposit of organic matter. In the month or so preceding cultivation, the sluices once again remain closed to block the entry of saltwater. Farmers prepare the plot for the new cultivation cycle by layering the ridges with accumulated deposits of swamp mud.

The creation of a mangrove rice system demands considerable labor for perimeter construction and desalination over a period of several years, as well as much effort annually to maintain the system's earthworks. But the reward for such monumental labor is yields that frequently exceed 2 tons per hectare. Besides displaying the range of soil- and water-management techniques developed for rice cultivation, the mangrove system illustrates a preexisting West African familiarity with the sophisticated earthworks infrastructure long associated with the South Carolina and Georgia tidal rice plantation.

The complex soil- and water-management principles embodied in planting rice along a landscape gradient in interconnected environments illustrate the ingenuity that characterized West African rice production. Numerous affinities exist with the rice systems of South Carolina and the process of technology development in tidewater rice, the antebellum era's quintessential production system.

The Temporal and Spatial Discontinuities of Rice Cultivation in South Carolina and Georgia

By 1860 rice cultivation extended over 100,000 acres along the eastern seaboard from North Carolina's Cape Fear River to the St. Johns River in Florida and inland for some 35 miles along tidal waterways (fig. 6).[34] The antecedents of the rice plantation economy date to the first century of South Carolina's settlement (1670–1770), and especially to the decades prior to the 1739 Stono slave rebellion. Rice cultivation systems analogous to those in West Africa, using identical

[34] Albert Virgil House, *Planter Management and Capitalism in Ante-Bellum Georgia* (New York, 1954); James Clifton, "Golden Grains of White: Rice Planting on the Lower Cape Fear," *North Carolina Historical Review* 50 (1973): 365–93; and Clifton, "Rice Industry" (n. 2 above).

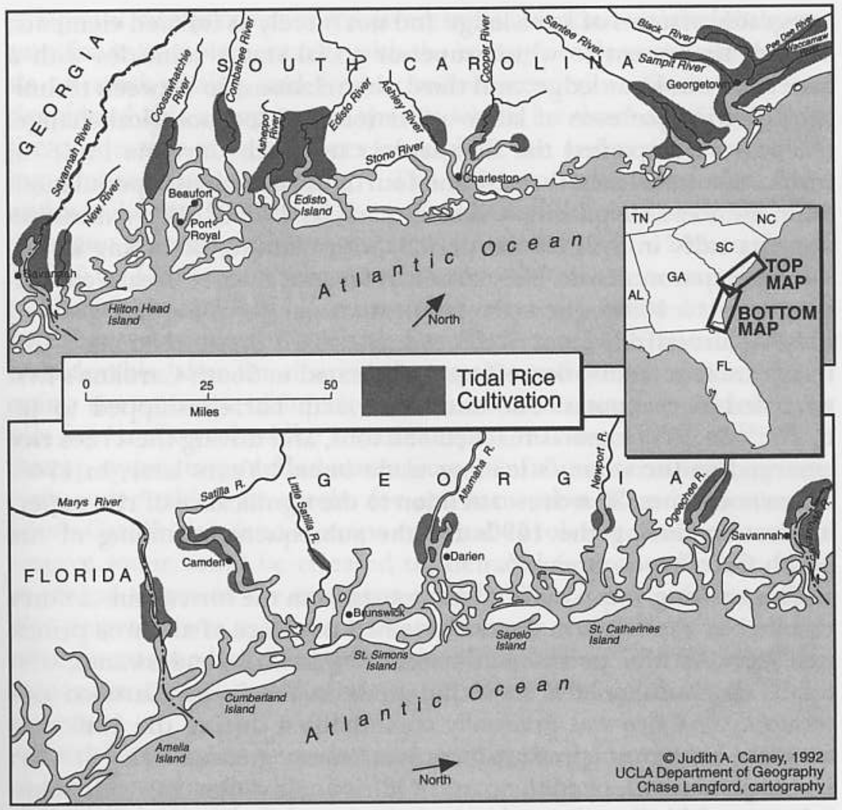

FIG. 6.—Tidewater rice cultivation in South Carolina and Georgia

principles and devices for water control, were already evident in this period. Dramatic increases in slave imports during the 18th century facilitated the evolution and commoditization of the South Carolina rice economy. The process of technology development, moreover, occurred in tandem with the emergence of the task labor system that distinguished coastal rice cultivation. Colonial rice production shifted respectively from reliance on rainfall to inland swamps and, from midcentury, to the tidal (tidewater) cultivation system that characterized the antebellum era.

This section presents an overview of the material conditions and historical circumstances within which rice production developed in South Carolina. The technical changes marking the evolution of the colonial rice economy illuminate three issues that bear on comparative studies of technology and culture: first, the need in cross-cultural analysis to examine the technical components of production as part of integrated systems of knowledge and not merely as isolated elements; second, the extent to which superior social status coincides with a superiority in knowledge; and third, the relationship between technical expertise, patterns of labor utilization, and technological change.

Slaves accompanied the first settlers to South Carolina in 1670; within two years they formed one-fourth of the colony's population, their numbers surpassing whites as early as 1708.[35] Rice cultivation appears early in the colonial period, with planting occurring in numerous environments. The earliest reference to the cereal's cultivation dates to 1690, when plantation manager John Stewart claimed to have successfully sown rice in twenty-two different locations.[36] Just five years later cultivation efforts culminated in South Carolina's first recorded rice exports: one and one-fourth barrels shipped to Jamaica.[37] In 1699 exports reached 330 tons, and during the 1720s rice emerged as the colony's leading trade item.[38] Years later, in 1748, Governor James Glen drew attention to the significance of rice experimentation during the 1690s for the subsequent unfolding of the South Carolina economy.[39]

The growing emphasis on rice exports from the turn of the century resulted by the 1740s in the documented presence of all three principal West African production systems: upland, inland swamp, and tidal.[40] Each dominated a specific phase in the South Carolina rice economy. As rice was gradually commodified during the 18th century, the numerous production environments mentioned by Stewart no longer characterized the pattern of rice cultivation. Instead, planting occurred in specific environments selected for emphasis at different moments in the crop's evolution as a commodity.

[35] P. Wood (n. 4 above), pp. 25–26, 36, 143–45. Eugene Sirmans, *Colonial South Carolina* (Chapel Hill, N.C., 1986), p. 24, claims that South Carolina showed a preference for slave, rather than indentured, labor from the earliest period of settlement. He attributes this anomaly before development of a plantation economy to the role of African labor. Perhaps the argument merits extension to the value of African knowledge of rice cultivation.

[36] P. Wood, pp. 57–58.

[37] Clifton, "Rice Industry," p. 269 and n. 11, same page.

[38] P. Wood, p. 55.

[39] Ibid., pp. 57–58. No official document mentions rice planting before 1690 even though it was considered a suitable crop for Carolina by Spanish, French, and English officials prior to the colony's settlement. See Clifton, "Rice Industry" (n. 2 above), p. 270, for the earliest indirect evidence for rice growing in South Carolina, when several English runaways to St. Augustine, Florida, claimed in 1674, "some rice . . . grown on the soil was shipped to Barbados."

[40] Doar (n. 3 above); Kovacik and Winberry (n. 7 above); Judith Carney and Richard Porcher, "Geographies of the Past: Rice, Slaves and Technological Transfer in South Carolina," *Southeastern Geographer* 33 (1993): 127–47.

Upland rice production received initial emphasis in the 18th century for its complementarity with the colony's early economic emphasis on stock raising and forest-product extraction. Slave labor underpinned this agropastoral system, which involved clearing forests, the production of naval stores (pine pitch, tar, and resin), cattle herding, and subsistence farming.[41] The export of salted beef, deerskins, and naval stores generated the capital for additional slaves. With the dramatic increase in slave imports (from 3,000 in 1703 to nearly 12,000 by 1720) rice cultivation shifted to the inland swamp system.[42]

The higher-yielding inland swamp system represented the first attempt at water control in South Carolina's rice fields but demanded considerable labor for clearing the cypress and gum trees and developing the network of bunds and sluices necessary for converting a plot into a reservoir. Like its counterpart in West Africa, the inland swamp system impounded water from rainfall, subterranean springs, high water tables, or creeks for soil saturation. Rice cultivation in South Carolina's inland swamps eventually evolved to the point where reserve water could be released on demand for controlled flooding at critical stages of the cropping cycle.[43] The objective of systematic plot irrigation was to drown unwanted weeds and thereby reduce the labor spent weeding. The principle of controlled field flooding was analogous to the one found in the West African mangrove rice system.

Field flooding for irrigation and weed control occurred in a variety of inland swamp settings. For instance, swamps located within reach of streams or creeks often used the landscape gradient for supple-

[41] John S. Otto, *The Southern Frontiers, 1607–1860* (New York, 1989); P. Wood (n. 4 above), pp. 30–32, 105–14; Terry Jordan, *Trails to Texas: Southern Roots of Western Cattle Ranching* (Lincoln, Nebr., 1981), pp. 14, 29, 33.

[42] On numbers of imported slaves, see Clowse (n. 4 above), p. 252; P. Wood (n. 4 above), pp. 143–45; Peter Coclanis, *The Shadow of a Dream* (New York, 1989), p. 64. For descriptions and periodization of the rainfed and inland swamp systems, see Thomas Nairne, "A Letter from South Carolina," in *Selling a New World: Two Colonial South Carolina Promotional Pamphlets,* ed. Jack Greene (1710; reprint, Columbia, S.C., 1989), pp. 33–73; Lewis Gray, *History of Agriculture in the Southern U.S. to 1860* (Gloucester, Mass., 1958), 1:279; Clifton, *Life and Labor* (n. 2 above); Clarence Ver Steeg, *Origins of a Southern Mosaic* (Athens, Ga., 1984); Otto (n. 41 above).

[43] Heyward (n. 3 above); Sam B. Hilliard, "Antebellum Tidewater Rice Culture in South Carolina and Georgia," in *European Settlement and Development in North America: Essays on Geographical Change in Honour and Memory of Andrew Hill Clark,* ed. James Gibson (Toronto, 1978), pp. 91–115; Richard Porcher, "Rice Culture in South Carolina: A Brief History, the Role of the Huguenots, and the Preservation of Its Legacy," *Transactions of the Huguenot Society of South Carolina* 92 (1987): 11–22; David Whitten, "American Rice Cultivation, 1680–1980: A Tercentenary Critique," *Southern Studies* 21 (1982): 5–26.

mental water delivery. Placement of an embankment at the low end of an undulating terrain kept water on the field while the upper embankment dammed the stream for occasional release. Sluices positioned in each earthen embankment facilitated field drainage and irrigation.[44]

Similar principles sometimes permitted rice planting in coastal marshes near the ocean.[45] Under special circumstances—where a saltwater marsh was located near the terminus of a freshwater stream, for example—rice planting occurred in soils influenced by the Atlantic Ocean. The conversion of a saline marsh to a rice field depended on soil desalination, a result not so quickly achieved under South Carolina's lower annual precipitation (1,100–1,200 mm) as in West Africa, where rainfall in tidal rice-growing areas generally exceeds 1,500 mm per year. Often a creek or stream served the purpose of rinsing salts from the field. Once again the water control system relied on proper placement of embankments and sluices. The lower embankment permanently blocked the inflow of saltwater at high tide, while opening the sluice at low tide enabled water discharge from the plot. A sluice positioned in the upper embankment delivered stream water as needed for desalination, irrigation, and weed control. This type of inland swamp system functioned in the vicinity of the embouchure of the Cooper River, where "rice marshes tempted planters as far down the river as Marshlands [Plantation], nearly within sight of the ocean. Here they had to depend entirely on 'reserve' waters formed by damming up local streams."[46]

The principle of canalizing water for controlled flooding also extended to settings where subterranean springs flowed near the soil surface. Edmund Ravenel described one system that continued to function until the Civil War: "The water here issues from the marl which is about two or three feet below the surface at this spot. This water passes South and is carried under the Santee Canal in a Brick Aqueduct, to be used on the Rice-Fields of Wantoot Plantation."[47]

During the antebellum period another inland swamp system func-

[44] Clifton, "Rice Industry" (n. 2 above), p. 275.

[45] Hawley (n. 3 above).

[46] John B. Irving, *A Day on the Cooper River* (Charleston, S.C., 1969), p. 154. The remains of a similar system can be seen behind Murphy Island in the Santee Delta, where an extensive salt marsh is located near a freshwater stream, and at Drayton Hall on the Ashley River.

[47] Edmund Ravenel, "The Limestone Springs of St. John's, and their probable Availability for increasing the quantity of Fresh Water in Cooper River," *Proceedings of the Elliott Society of Science and Art, of Charleston, South Carolina* 2 (October 1860): 28–31, quote on 29.

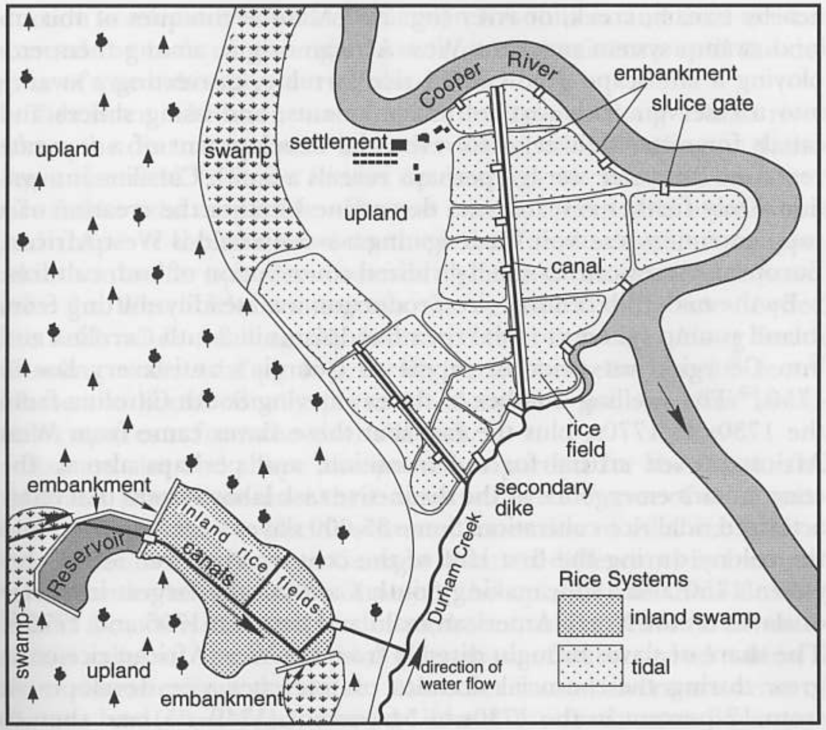

FIG. 7.—Inland and tidewater rice system, west branch of the Cooper River, South Carolina. (Adapted from R. Porcher, *A Field Guide to the Bluff Plantation* [New Orleans, 1985], p. 266.)

tioned alongside tidewater rice cultivation. While its colonial antecedents remain uncertain, this system flourished where a landscape gradient sloped from rainfed farming to the inner edge of a tidal swamp.[48] Enclosing a tract of land with earthen embankments on high ground created a reservoir for storing rainwater, the system's principal water source. The reservoir fed water by gravity flow to the inland rice field through a sluice gate and canal (fig. 7). Excess water flowed out of the plot through a drainage canal and sluice, placed along the lower end of the rice field. The water then drained into a

[48] Hilliard (n. 43 above) points out that during much of the 18th century both inland swamp fields with reservoirs and tidewater rice existed simultaneously and that freshwater reservoirs were common even on plantations situated within or near the tidal zone: "In many cases there must have been a blending of the two types of irrigation, for Solon Robinson observed a tidewater planter on the Cooper River who had 'ponds of fresh water covering 100 acres of upland, which are held in reserve to water the rice fields when the river is too salt' " (p. 99).

nearby stream, creek, or river (fig. 7).[49] Many techniques of this inland swamp system suggest a West African origin, among them employing a landscape gradient for rice farming, converting a swamp into a reservoir with earthen embankments, and using sluices and canals for water delivery. However, the development of a separate reservoir for water storage perhaps reveals a South Carolina innovation. Only further research can determine whether the creation of a supplementary reservoir for irrigating a swamp field is West African, European-American, or the hybridized contribution of both cultures.

By the mid-18th century rice production was steadily shifting from inland swamp systems to tidal river floodplains in South Carolina and into Georgia, just prior to repeal of Georgia's antislavery law in 1750.[50] The swelling number of slaves entering South Carolina from the 1730s to 1770s, plus the fact that these slaves came from West Africa, proved crucial for the transition, and perhaps also to the concomitant emergence of the distinctive task labor system that characterized tidal rice cultivation. Some 35,000 slaves were imported into the colony during the first half of the century and over 58,000 between 1750 and 1775, making South Carolina the largest importer of slaves on the North American mainland between 1706 and 1775.[51] The share of slaves brought directly from the West African rice coast grew during these crucial decades of tidewater rice development from 12 percent in the 1730s to 54 percent (1749–65) and then to 64 percent between 1769 and 1774.[52]

One of the earliest references to the existence of the tidal floodplain system appeared in 1738 with notice of a land sale by William Swinton of Winyah Bay, South Carolina: "that each [field] contains as much River Swamp, as will make two Fields for 20 Negroes, which is overflow'd with fresh Water, every high Tide, and of Consequence not subject to the Droughts."[53] By 1752 rich Carolina planters were converting inland swamps and tidal marshes along Georgia's Savannah and Ogeechee rivers to rice fields, a process actively under way during the 1772 visit by naturalist William Bartram.[54] The shift to tidal production accelerated after the American Revolution, and tidal rice remained the basis of the region's economic prominence until the demise of rice cultivation during the 1920s.[55]

[49] Porcher, "Rice Culture in South Carolina" (n. 43 above).

[50] Wilms (n. 2 above); Smith, *Slavery and Rice Culture* (n. 2 above).

[51] David Richardson, "The British Slave Trade to Colonial South Carolina," *Slavery and Abolition* 12 (1991): 125–72, esp. 127–28.

[52] Ibid., pp. 135–36.

[53] *South Carolina Gazette,* January 19, 1738; Clifton, "Rice Industry" (n. 2 above), pp. 275–76, observes notices of tidal swamps for sale first appearing during the 1730s in the *South Carolina Gazette*—1731 for Cape Fear River and 1737 for the Black River in South Carolina.

[54] Wilms, p. 49.

Tidewater cultivation occurred on floodplains along a tidal river where the diurnal variation in sea level resulted in flooding or draining a rice field.[56] Three factors determined the siting of tidewater rice fields: tidal amplitude, saltwater encroachment, and estuary size and shape. A location too near the ocean faced saltwater incursion, while one too far upstream removed a plantation from tidal influence. Like the West African mangrove rice system, a rising tide flooded the fields while a falling tide facilitated field drainage. Along South Carolina rivers tidal pitch generally varied between 1 and 3 feet.[57] These conditions usually prevailed along riverine stretches 10–35 miles upstream from the river's mouth.[58]

Estuary size and shape also proved important for the location of tidewater plantations since these factors affected degree of water mixing and thus salinity. The downstream extension of tidal rice cultivation in South Carolina and Georgia reflected differences in freshwater dynamics between rivers draining the uplands and those flowing inland from the sea. As rivers of piedmont origin deliver freshwater within miles of the coast, tidal cultivation often occurred within a short distance from the ocean. But other coastal rivers are arms of the sea and must reach further inland for freshwater flows (see fig. 6). Along such rivers the freshwater stream flow forms a pronounced layer on top of the heavier saltwater, thereby enabling tapping of the former for tidal irrigation.[59] Success under these conditions depended on knowledgeable observation of tidal flows and the manipulation of saltwater-freshwater interactions to achieve high productivity levels in the rice field—skills already belonging to West African tidal rice farmers.

Preparation of a tidal floodplain for rice cultivation followed principles remarkably similar to the mangrove rice system (compare figs. 5 and 7). Figure 8 shows the sequence of steps in the conversion of floodplain to rice paddy. The rice field was embanked at sufficient height to prevent tidal spillover, the process leaving a canal adjacent to the embankment. Sluices built into the embankment and field sec-

[55] Clifton, "Rice Industry," p. 276.

[56] Hilliard (n. 43 above), p. 100.

[57] Chaplin (n. 28 above).

[58] John Drayton, *View of South Carolina* (1802; reprint, Spartanburg, S.C., 1972), p. 36; Chaplin, p. 231.

[59] Hilliard.

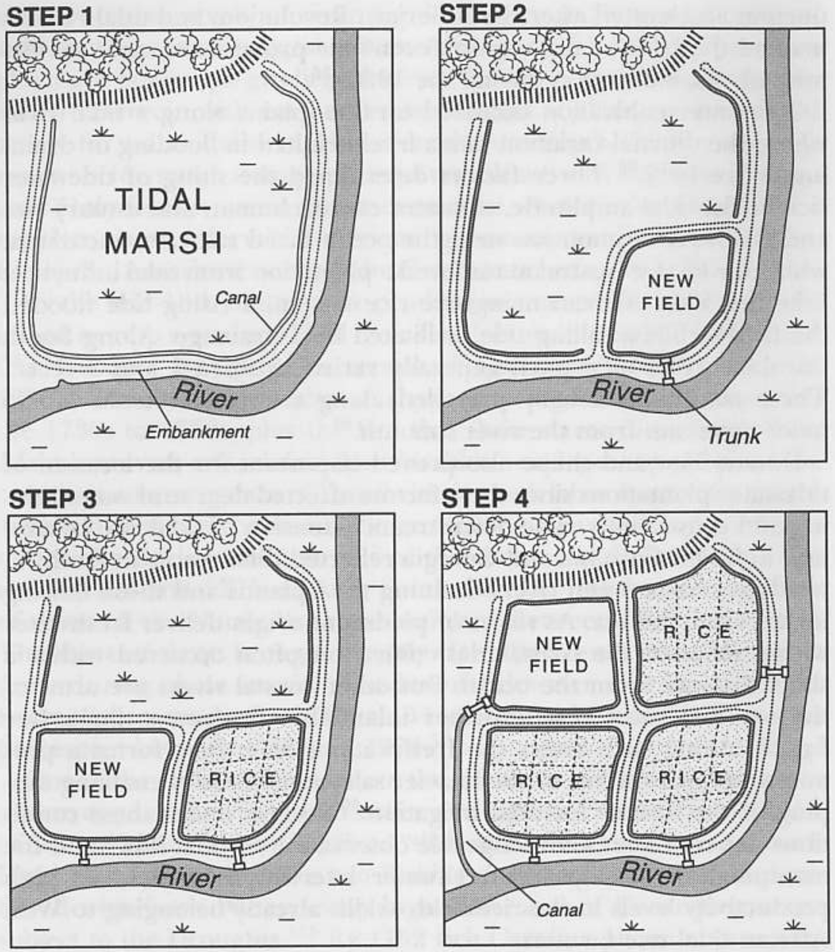

FIG. 8.—Tidewater swamp conversion, South Carolina. (Adapted from S. Hilliard, "Antebellum Tidewater Rice Culture in South Carolina and Georgia," in *European Settlement and Development in North America: Essays on Geographical Change in Honour and Memory of Andrew Hill Clark*, ed. J. Gibson [Toronto, 1978], p. 106.)

tions operated as valves for flooding and drainage much as they do in Africa's mangrove rice system (figs. 5 and 7). The next step involved dividing the area into quarter sections of 10–30 acres, with river water delivered to these sections through secondary ditches. This elaborate system of water control enabled slaves to directly sow rice along the floodplain.

Tidewater cultivation required considerable landscape modification and even greater numbers of laborers than the rice-growing

systems that first featured prominently in the South Carolina economy. The labor in transforming tidal swamps to rice fields proved staggering, as vividly described by historical archaeologist Leland Ferguson:

> These fields are surrounded by more than a mile of earthen dikes or "banks" as they were called. Built by slaves, these banks . . . were taller than a person and up to 15 feet wide. By the turn of the eighteenth century, rice banks on the 12½ mile stretch of the East Branch of Cooper River measured more than 55 miles long and contained more than 6.4 million cubic feet of earth. . . . This means that . . . working in the water and muck with no more than shovels, hoes, and baskets . . . by 1850 Carolina slaves . . . on [tidal] plantations like Middleburg throughout the rice growing district had built a system of banks and canals . . . nearly three times the volume of Cheops, the world's largest pyramid.[60]

The earthen infrastructure continued to make considerable demands on slave labor for maintenance even as it reduced labor spent weeding rice plots.[61] With full water control from an adjacent tidal river, the rice crop could be flooded on demand for irrigation and weeding, and the field renewed annually by alluvial deposits. Historian Lewis Gray underscored the significance of tidal flow for irrigation as well as weeding in explaining the shift from the inland swamp rice system to tidewater cultivation: "Only two flowings were employed [inland swamp] as contrasted with the later period when systematic flowings [tidal] came to be largely employed for destroying weeds, a process which is said to have doubled the average area cultivated per laborer. . . . The later introduction of water culture [tidal] consisted in the development of methods making possible a greater degree of reliance than formerly on systematic raising and lowering

[60] Leland Ferguson, *Uncommon Ground: Archaeology and Early African America, 1650–1800* (Washington, D.C., 1992), pp. xxiv–xxv, 147.

[61] This herculean toil is likely responsible for the gradual demise of tidewater cultivation after emancipation and for freedmen's avoidance of "mud work" as hired labor on tidal plantations even as they continued to grow rice on their own as a cash crop in some inland swamps of South Carolina until the 1930s; see, e.g., Amelia Wallace Vernon, *African Americans at Mars Bluff, South Carolina* (Baton Rouge, La., 1993). Vernon documents the survival of rice cultivation among African Americans as a response to blacks' restricted access to farmland following Reconstruction. Cultivating rice as a cash crop on unclaimed swamps represented an important form of resistance to the prevailing exploitative wage labor and sharecropping relations that emerged. Planting the crop of their forebears consequently nurtured freedmen's dreams of independent farming, the failed promise of Reconstruction.

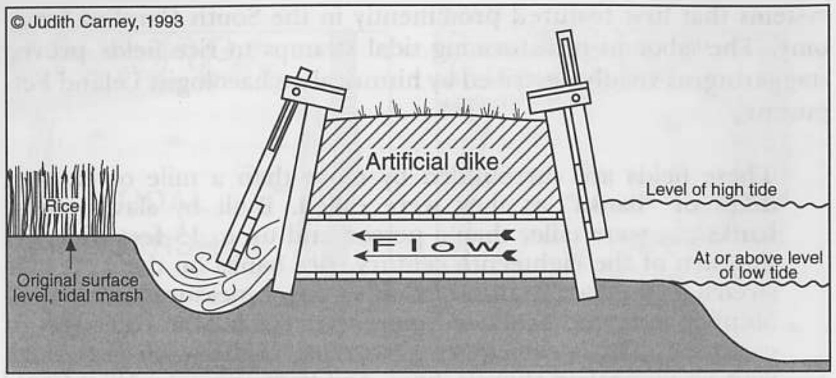

FIG. 9.—Cross section of tidewater rice trunk. (Adapted from R. Porcher, "Rice Culture in South Carolina: A Brief History, the Role of the Huguenots, and the Preservation of Its Legacy," *Transactions of the Huguenot Society of South Carolina* 92 [1987]: 6.)

of the water."[62] A slave consequently could manage 5 acres instead of the two typically assigned with inland rice cultivation.[63]

The systematic lifting and lowering of water noted by Gray was achieved by the sluices located in the embankment and secondary dikes (fig. 7). These crucial devices for water control had assumed the form of hanging floodgates by the late colonial period.[64] As this type of sluice is not traditionally found in West Africa, the hanging gate probably is of European-American origin. Even when this gate replaced earlier forms, the sluices maintained the appellation "trunk" by Carolina planters. The continued use of this term throughout the antebellum period suggests that the technological expertise of Africans indeed proved significant for establishing rice cultivation in the earlier colonial era. During the antebellum period trunks evolved into large floodgates, anchored into the embankment at a level above the usual low tide mark (fig. 9). Doors (gates) placed at both ends would swing when pulled up or loosened. The inner doors opened in response to river pressure as the water flowed through the raised outer door and then closed when the tide receded. Field draining

[62] Gray (n. 42 above), p. 281.

[63] R. F. W. Allston, "Essay on Sea Coast Crops," *De Bow's Review* 16 (1854): 589–615; James Glen, "A Description of South Carolina: Containing Many Curious and Interesting Particulars Relating to the Civil, Natural and Commercial History of That Colony," in *Colonial South Carolina: Two Contemporary Descriptions,* ed. Chapman J. Milling (Columbia, S.C., 1951), p. 15; Clifton, "Rice Industry" (n. 2 above), p. 275; Whitten (n. 43 above), pp. 9–15.

[64] Richard Porcher, *A Field Guide to the Bluff Plantation* (New Orleans, 1985), pp. 26–27.

reversed the arrangement, with the inner door raised and the outer door allowed to swing while water pressure in the field forced the door open at low tide.[65]

Curiosity over the origin of the term "trunk" for sluices or floodgates led planter descendant David Doar to unwittingly stumble on likely technology transfer from West Africa:

> For years the origin of this name bothered me. I asked every old planter I knew, but no one could enlighten me. One day a friend of mine who planted on one of the lowest places . . . said to me with a smiling face: "I have solved that little trunk question. In putting down another one, I unearthed the granddaddy of plug trunks made long before I was born." It was simply a hollow cypress log with a large hole from top to bottom. When it was to be stopped up a large plug was put in tightly and it acted on the same principle as a wooden spigot to a beer keg.[66]

The earliest sluice systems in South Carolina looked and functioned exactly like their African counterparts.

Tidewater cultivation led South Carolina to economic prominence in the antebellum era. Its appearance in the colony from the 1730s, and rapid diffusion from midcentury, occurred during a period of escalating slave imports from Africa's rice coast. The evidence presented here concurs with Wood's original claim that Africans tutored planters in developing South Carolina's rice economy. The African experience with planting a whole range of interconnected environments along a landscape gradient likely permitted the sequence of adaptations that marked the growth of the South Carolina rice industry. While the overview of rice cultivation in South Carolina suggests that planters indeed reaped the benefits of a rice farming system perfected by West Africans over millennia, an important question remains: why would West African slaves transfer a sophisticated technology of rice cultivation to the planters when the result harnessed them to brutal toil in malarial swamps?

The answer is perhaps revealed in the appearance of an innovative form of labor organization, the task system, that characterized coastal rice plantations from the mid-18th century. Task labor differed sharply from the more typical "gang" form of work organization, as Gray explains: "Under the task system the slave was assigned a certain amount of work for the day, and after completing the task he could use his time as he pleased." In the gang system "the laborer

[65] House (n. 34 above), p. 25.

[66] Doar (n. 3 above), p. 12.

was compelled to work the entire day."[67] Without overstating the differences in workload between gang and task labor, the task system did set normative limits to the number of hours demanded of slave labor. Such seemingly minor differences, however, could deliver tangible improvements in slave nutrition and health, as Johan Bolzius implied in 1751 with his observation: "If the Negroes are Skilful and industrious, they plant something for themselves after the day's work."[68]

The emergence of the task labor system in South Carolina during the same historical period as accelerating slave imports from West Africa's rice coast and tidewater development is perhaps significant. This form of labor organization may have represented the outcome of negotiation and struggle between master and slave over agronomic knowledge and the labor process. By providing the crucial technological basis for plantation profits, slaves perhaps discovered a mechanism to negotiate improved conditions of bondage. Additional research on the task labor system, whose origins may be African, promises to illuminate the complex relationship between patterns of labor utilization and technical expertise in slave-based plantation systems.[69]

Conclusion

"What skill they displayed and engineering ability they showed when they laid out these thousands of fields and tens of thousands of banks and ditches in order to suit their purpose and attain their ends! As one views this vast hydraulic work, he is amazed to learn that all of this was accomplished in face of seemingly insuperable difficulties by every-day planters who had as tools only the axe, the spade, and the hoe, in the hands of intractable negro men and women, but lately brought from the jungles of Africa."[70] When Doar echoed in 1936 the prevailing view that slaves contributed little besides labor to the evolution of the South Carolina rice economy, no historical research suggested otherwise. While more recent research challenges such assumptions, a bias nonetheless endures against considering the prior rice cultivation experience of African slaves in the

[67] Gray (n. 42 above), pp. 550–51; Philip Morgan, "Work and Culture: The Task System and the World of Low Country Blacks, 1700 to 1880," *William and Mary Quarterly,* 3d ser., 39 (1982): 563–99; Smith, *Slavery and Rice Culture* (n. 2 above), p. 61.

[68] Bolzius quoted in Morgan, p. 565. The entire document appears in "Johan Bolzius Answers a Questionnaire on Carolina and Georgia," ed. and trans. Klaus G. Loewald, Beverly Starika, and Paul Taylor, *William and Mary Quarterly,* 3d ser., 14 (1957): 218–61.

[69] Carney, "From Hands to Tutors" (n. 15 above), pp. 26–28.

[70] Doar, p. 8.

context of the crop's appearance during the 18th century in several areas of the Americas.

In his classic book on global rice cultivation, now in multiple editions, D. H. Grist describes the mangrove system when he writes about empoldering as "a method of restricting floods and thus securing adjacent areas from submergence."[71] He is referring to a type of paddy rice cultivation found in British Guiana (now Guyana) and in the neighboring former Dutch colony of Surinam. On its origins he hypothesizes: "The Dutch are probably responsible for introducing this system into British Guiana in the eighteenth century. Today, all the land developed for paddy cultivation and in the adjacent Dutch colony of Surinam is protected by this means."[72]

This area of northern South America in the late 17th through early 18th centuries, however, was a plantation society with one of the highest ratios of Africans to Europeans in the Americas (65:1 in Surinam's plantation districts, compared to Jamaica's 10:1).[73] Slave imports continued well into the 18th century, with a high percentage originating from the West African rice area discussed by Dutch geographer Dapper in the previous century.[74] Grist's perfunctory treatment of *Oryza glaberrima* in his book (due to the species being "confined to small areas in West Africa . . . [and thus] . . . relatively unimportant") is emblematic of a more pervasive scholarly view toward Africa and its peoples as having contributed little across geographic space besides labor.[75]

This view, however, is giving way as new evidence comes to light from several academic disciplines informed by multicultural and cross-cultural perspectives. Recent studies suggest that Europeans and people of European descent can no longer be viewed as the sole masters of technology development and innovation.[76] Yet research

[71] D. H. Grist, *Rice,* 4th ed. (London, 1968), p. 45. This comment also suggests the need for additional research on how the Dutch used poldering techniques for agriculture.

[72] Ibid.

[73] See, e.g., Richard Price and Sally Price, *Stedman's Surinam: Life in an Eighteenth-Century Slave Society* (Baltimore, 1992), pp. xii, 208–19. Fugitive slave communities in 18th-century Surinam widely cultivated rice, experienced abundant harvests, transferred the crop between communities, and even took their eponyms from rice, such as Reisse Condre (translation: from the quantity of rice it afforded).

[74] Ibid.

[75] Grist, p. 56.

[76] Doar (n. 3 above), p. 20, once again illustrates this Eurocentric bias against African as well as Asian knowledge systems in his 1936 book: "It is one hundred and fifty-seven years [*sic*] since the introduction of rice into Carolina, and there are grounds for supposing that our people have accomplished more during that period, in the cultivation and preparation of this grain, than has been done by any Asiatic nations, who have been conversant with its growth for many centuries." Recent work that counters

on the origins of the rice plantation economy in South Carolina and Georgia displays a lingering Eurocentric bias, granting slaves an initial role in the inland swamp rice system but attributing to planters the crucial technological development of water control that led to tidewater rice cultivation: "Slaves who had experience growing rice in West Africa were probably instrumental in the successful creation of early rice plantations. . . . Some prescient innovators realized that the system would eventually yield diminishing returns and looked for an alternative way to irrigate their crops. The diurnal rising and falling of coastal rivers, caused by the flow and ebb of ocean tides, seemed a likely source of irrigation water. . . . As early as the 1730s, planters noted tidal flow in rivers and, gingerly, began to flow estuarial water over their fields."[77]

The cross-cultural and historical perspective on two important rice-growing regions of the Atlantic basin presented here suggests otherwise. Evidence from the first fifty years of settlement in South Carolina supports the view that technological development and innovation in the rice economy began as an African knowledge system but eventually bore the imprimatur of both African and European influences.[78] By the American Revolution the technological and agronomic heritage of each knowledge system had combined in new ways to shape rice cultivation along the south Atlantic coast of the United States, a process that Paul Richards terms "agrarian creolization."[79] By way of analogy with its linguistic namesake, Richards is referring to the convergence of different knowledge systems (e.g., germ plasm resources and cultivation strategies—in this example, African and Asian germ plasm and African cultivation strategies) and their recombination into new hybridized forms. The outcome of this convergence in South Carolina was a rice production system fashioned from an indigenous African crop that came to bear the distinctive signature of European as well as African culture. Thus, as Africans and Europeans faced each other in new territory under dramatically altered and unequal power relations, the outcome was diffusion, technological innovation, and novel forms of labor organization.

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the attribution of European political-economic hegemony to technological superiority over other cultures is presented in Michael Adas, *Machines as the Measure of Men* (Ithaca, N.Y., 1989); and Jim Blaut, "On the Significance of 1492," *Political Geography* 11 (1992): 355–85.

[77] This is the point of view set forth by Chaplin (n. 28 above), pp. 228–36, in a recent and masterful study on agricultural innovation in the Lower South; quotes are from pp. 228, 231, 232.

[78] See, e.g., ibid., pp. 147–50, for possible diffusion of Asian rice techniques and technologies into South Carolina via the botanical gardens and scholarly societies that proliferated with European political-economic expansion across the globe.

[79] Richards, "Culture and Community Values" (n. 16 above), p. 2. Several decades ago, Melville Herskovits drew attention to the significance of the idea of cultural "creolization" for research: "The problem . . . was the manner in which elements of European, African and . . . American Indian cultures had exerted mutual influences." Melville Herskovits, in *The New World Negro: Selected Papers in Afroamerican Studies*, ed. Frances Herskovits (Bloomington, Ind., 1966), pp. 36–37.