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Southeastern Geographer, Volume 33, Number 2, November 1993, pp.
127-147 (Article)

Published by The University of North Carolina Press

DOI: <https://doi.org/10.1353/sgo.1993.0000>

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GEOGRAPHIES OF THE PAST: RICE, SLAVES AND TECHNOLOGICAL TRANSFER IN SOUTH CAROLINA¹

Judith Carney and Richard Porcher

This paper examines the plausibility for an African transfer of technology to the South Carolina ante-bellum rice economy. Emphasis is on the colonial period when three distinct rice production systems emerged. A cross-cultural and geographical analysis is employed to examine the spatial patterns of rice growing between South Carolina and West Africa. The analysis demonstrates a remarkable correspondence between micro-environments planted to rice as well as the field and irrigation techniques utilized for production.

The rice plantation economy of South Carolina has received considerable geographic and historical attention for its role in the regional economic development of the ante-bellum South. Rice sustained the South's most prosperous plantation economy and by the mid-1800s had expanded over 150,000 acres of tidal swamps (Morgan, 1974; Gresham and Hook, 1982; Wilms, 1972).² The plantation system imposed onerous work demands on slaves who radically transformed the landscape and implemented the sophisticated irrigation infrastructure.

Geographers interested in the human-environmental interactions mediating the region's economic development have contributed to the area's research in two important ways: first, by outlining the manner in which rice development unfolded temporally across geographic space; and, second, by identifying the cultural and historical factors that shaped the distinctive rice landscape (Kovacik, 1982; Kovacik and Winberry, 1987; Brown, 1943; Wilms, 1972; Hilliard, 1975; Meinig, 1986; Earle, 1992). This work complements historical scholarship over the past 20 years which has drawn attention to the social context of colonial rice development and, particularly, the role of West African slaves in the emergence of the South Carolina rice economy (Wood, 1974b; Ver Steeg, 1975; Joyner, 1984; Otto, 1989; Littlefield, 1981; Palmer, 1992).

Until the mid-1870s slaves were regarded merely as unskilled labor, contributing nothing but their brawn to the creation of a rice economy.

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This view began to shift with historical research that demonstrated planter unfamiliarity with rice cultivation and yet the widespread knowledge of rice planting among Africans enslaved from Senegal to the Ivory Coast—a region known as the Rice Coast during the Atlantic slave trade (Wood, 1974b; Littlefield, 1981). Evidence of planter preference for slaves from rice-growing regions of West Africa contributed to a new outlook on the role of Africans in the South Carolina rice economy, *viz.*, that they may have contributed skilled labor and, perhaps, knowledge of rice farming to the New World (Wood, 1974b, pp. 8, 54).

But direct evidence demonstrating that slaves provided the critical knowledge for rice cultivation during the early colonial period has yet to receive documented support. This may prove an elusive objective given scant 17th century records but also and, importantly, because, in transforming Africans into “animated chattel,” the condition of bondage denied slaves their own history (Genovese, 1972; Wolf, 1982). By placing accounts of their lives in the hands of white society, which over time likened their mental acumen to children, slavery as an institution could easily efface the role of Africans in colonial rice development.

This paper takes a different approach to examining the plausibility of a technology transfer of rice cultivation to South Carolina by African slaves. A geographic framework is employed to compare the spatial relationships between rice cultivation in West Africa and South Carolina. Emphasis is placed on a cross-cultural analysis of the micro-environments planted to rice as well as the field and water management techniques developed for planting in West Africa and South Carolina.

Drawing upon empirical and historical research in both regions, the paper begins by identifying the primary lowland environments planted to rice on each side of the Atlantic. A classification system is formulated to describe the water and soil management principles mediating rice planting in distinct West African micro-environments as well as the devices developed to regulate water level for field flooding and drainage. The discussion then shifts to South Carolina where archival and empirical research is used to illustrate the spatial and temporal unfolding of identical systems with increasing slave imports during the first half of the 18th century.

West African Rice Cultivation Systems. When the Portuguese arrived along the West African coast in the mid-15th century, they encountered

rice cultivation over a broad area from Gambia to Sierra Leone (Fig. 1). Rice farming is indigenous to West Africa and dates back at least three thousand years (Charbolin, 1977; Linares, 1981). *Oryza glaberrima*, the native African rice, was originally domesticated in the delta of the middle Niger River with an important secondary center of variation along Senegambian floodplains (Fig. 1). Asian *O. sativa* varieties, which currently dominate production, were introduced into West Africa by the Portuguese or, earlier, via trans-Saharan trade routes (Porteres, 1970; Harlan et al., 1976; Carpenter, 1978; Chang, 1989).

Islamic scholars following long-established inland trade routes drew attention to the prevalence of rice growing along the Niger River during the mid-14th century and its cultivation on floodplains (Gibb, 1969; Lewicki, 1974). But the system found along coastal estuaries, which closely corresponded with the one that led to South Carolina's ante-bellum prosperity, awaited notice until the arrival of European traders and slavers from the 1450s. Their commentaries provide the detail and the identifying features of the major West African cultivation zones planted to rice which paralleled those to emerge in South Carolina. The historical record clearly indicates that prior to contact with Europeans African

Fig. 1. West African Rice Production Zone. Source: Adapted from Richards 1987.

rice culture had reached sophisticated proportions. Rice continues to be cultivated in the variety of environments discussed in this paper and remains the basic dietary staple to millions of West Africans today.

The West African rice zone extends along the Atlantic littoral from Senegal to the Ivory Coast and inland to the Niger Delta in Mali (Fig. 1). West Africa is a region of considerable ecological diversity and precipitation variability, embracing more diverse production systems and agronomic practices than those found in Asia, the other major geographical area of rice evolution (Viguier, 1939; Littlefield, 1981). A marked distinction of the West African rice cultivation system is its ability to utilize a variety of moisture regimes for production.

Rainfall in the West African rice zone averages between 1100–1600 mm, a range similar to that found in the Lowcountry of South Carolina and Georgia (Carney, 1986; Kovacik and Winberry, 1987; Silver, 1990). Within the West African rice region precipitation steadily increases from north to south, with slightly higher averages along the coast. African rice cultivation is not, however, limited by pluvial constraints. Over the past three millennia farmers carefully adapted rice production to other forms of water availability by planting moisture-holding soils, using depressions fed by underground springs or high water tables, and floodplains inundated by tidal flow. Consequently, rice cultivation occurs in a variety of micro-environments which include mangrove estuaries, alluvial floodplains, lacustrine basins, low-lying depressions, grassland savannas, and upland forests. Rather than posing a constraint to production, West Africa's climatic and environmental diversity provided the stimulus for adapting rice-growing to both saline- and freshwater-influenced micro-environments (Richards, 1986). By adjusting agronomic practices to moisture regimes, topography, and edaphic factors, Africans evolved an agricultural system that extended the cropping season beyond pluvial limits, thereby enhancing subsistence security (Carney, 1991).

A schematic diagram of the primary rice production systems, classified by type of water availability, is presented in Figure 2. Three major water regimes are used for rice production: pluvial systems reliant solely

Fig. 2. Principal West African Rice Systems. Source: Carney fieldwork.

on rainfall for cultivation; phreatic rice, which draws supplemental water from moisture-holding clay soils, artesian springs, perched water tables, or catchment run-off; and fluxial rice, found along flood plains and estuaries, which receives irrigation from tides (Moorman and Veldkamp, 1978; WARDA, 1980). Within these three general conditions of water availability, West African farmers have adjusted rice cultivation to numerous micro-environments (Johnny et al., 1981).³ All but rainfed rice are grown in lowland swamps. The fluxial, or tidal, system includes two distinct micro-environments differentiated by whether saltwater incursion poses a cropping risk. Figure 2 presents the five sub-types (A–E) that were to emerge in South Carolina by the mid-18th century.

Pluvial. Upland rice depends solely on rainfall and is generally found in areas receiving more than 1100 mm precipitation. It is commonly cultivated on soils supporting mixed woodland vegetation which are partially cleared and burned of surface debris. The duration of the rainy season regulates varietal selection, which is usually of short duration (90–110 days). Declining fertility as well as labor demands for weeding and pest control generally lead to a fallow cycle after three to five years of cultivation. Fertility of the land is gradually restored by the manure of cattle which graze the successional grasses during the fallow rotation.

Phreatic. This second type of West African rice system frees production from precipitation constraints through the cultivation of soils and lowland swamps that trap supplemental moisture reserves. Phreatic rice occurs in a broad array of micro-environments that respond to farmer knowledge of soil saturation properties as well as to methods that facilitate water impoundment and drainage. Two of these micro-environments were also developed for rice production in colonial South Carolina: inland depressions with perched water tables or catchment run-off and low-lying areas fed by artesian springs.

In phreatic rice systems the accumulation of groundwater in the root zone extends the cropping period, but production requires careful attention to drainage and water control since rice seedlings are as sensitive to flooding as drought (Grist, 1968). Consequently, phreatic plots are often bunded and ridged. Enclosing the plot with earthen bunds creates a water reservoir which captures rainfall or stream run-off for soil saturation during dry cycles within the cropping season. Establishing the rice

plant on a ridge improves soil aeration and drainage while depressing weed growth. Water level is also frequently regulated by piercing the plot bunds with a system of sluices which operate as valves. Constructed from palms or bamboo and plugged with palm thatch, the sluices permit control over water inflow and outflow, a technique used not only for plot moisture requirements but also to drown noxious weeds.

Depending on water depth and duration of flooding, phreatic plots are sown to short or medium duration varieties. In areas continuously lubricated by artesian springs, more than one rice crop may be planted. The variability in moisture retention of the soil regulates decisions on whether to sow rice directly or to transplant the seedlings. Transplanting, however, is widely practiced, because it facilitates seedling survival in deeply flooded swamps. Establishing seeds first in rice nurseries near the village minimizes the risk of waterlogging; at about three weeks' growth, the seedlings can withstand tidal surges. Transplanting also contributes to higher yields since the process of pulling up the seedlings from nurseries strengthens the root system and promotes tillering, with the result that each plant bears several panicles instead of one. Transplanted rice is estimated to yield 40% more than directly seeded plots (Bray, 1983). Transplanting, moreover, enables farmers to place seedlings at regular intervals along rice ridges, a practice which facilitates weeding and pest control.

Phreatic rice generally occurs in micro-environments of small areal extent, but the cultivation system is valued because farmers are able to manipulate water availability for crop survival and weed reduction, which post major problems in upland rice cultivation.

Fluxial. In this last type of rice cultivation common to West Africa and South Carolina, rice is grown on riverine floodplains with tides supplying water requirements. The fluxial system depends upon the diurnal variation in river levels to flood and drain rice fields.

West African tidewater production systems are a function of coastal topography, ocean currents, and precipitation patterns. The numerous rivers emptying into the West African littoral have a low gradient, which means that strong marine currents are able to push saline water considerable distances upstream. Along the Gambia River, ocean currents contribute to permanently saline river conditions 70 kilometers from the coast and to seasonally brackish water as far as 250 kilometers upstream. Rice cultivation is adjusted to the duration of freshwater availability

during the wet season when the brackish water ebbs downstream. Beyond 250 kilometers, freshwater tides in the river enable year-round rice cultivation.

In the Gambia River region tidal rice involves minimal landscape manipulation. Sometimes an embankment is constructed between the river or tributary and the rice field to mitigate tidal surges, but more often a ribbon of mangroves is left in place to perform the same task. Floodplains planted include those flooded daily, as well as others receiving only high river and full moon tidal flows. The inner floodplain combines rainfall with tides for cultivation while the diurnally flooded area receives its moisture requirements principally from tidal action. Areas only periodically wetted by tidal action are broadcast with drought tolerant short duration seeds. Once rains cease, the crop matures from moisture reserves captured in the clay soils with flood recession. Floodplains lubricated by daily tidal flow, however, involve transplanting seed varieties that elongate rapidly, since water depth frequently exceeds one meter. Although the diurnally flooded zone expands and contracts seasonally, rice can be grown year round.

The rainy season opens up similar floodplain production systems downstream in areas seasonally influenced by brackish water. Rains push the saltwater interface downstream, enabling rice cultivation along stretches of the river that experience at least three months of freshwater—the maturation cycle of the shortest duration seed varieties. Agronomic techniques in the saline influenced zone are similar to those with freshwater tidal cultivation but for one detail: in years when the return of freshwater is delayed, the nurseries are double transplanted. Retransplanting strengthens panicle development which weakens if seedlings remain in nurseries after one month's growth.

A more elaborate refinement of rice cultivation in seasonally brackish environments prevails along rivers south of the Gambia where precipitation surpasses 1500 mm and falls over an extended wet season. By utilizing soils of high moisture-holding capacity and rainfall, rice cultivation can be extended to marine-influenced estuaries where freshwater tides are of brief duration. Swamp reclamation in these zones involves considerable landscape modification for water impoundment, drainage, and desalination. This is the production system that best illustrates African skill, ingenuity, and creativity in rice farming.

Vast expanses of mangroves (*Rhizophora* spp.) occur along the West African coast and estuaries. Their aerial roots trap sediments swept into

their reach by marine tides that can exceed one meter's pitch. These sediments contribute to the formation of some of the richest soils in the West African rice zone, but considerable care is required in their management for they contain variable amounts of pyrite (FeS_2) which will oxidize upon aeration and acidify. Under sophisticated management these potential acid-sulfate soils provide good rice yields, but to prevent intensive oxidation and the formation of a sulfuric horizon, seasonal inundation is required. If potential acid-sulfate soils are not kept lubricated, their pH over time can drop to 2.0, rendering them sterile for rice cultivation (Breeman and Pons, 1978). African farmers have developed sophisticated water management practices to minimize the acidification risk in order to capture the high yield potential of the soil's rich organic matter content.

Rice production is attuned to a precise knowledge of soils, marine tides and techniques to reclaim land from the sea and involves massive landscape alteration (Paulme, 1957; Pelissier, 1966; Linares, 1981; Handem, 1983). Land preparation begins with the selection of a swamp site for reclamation. Perimeter size is regulated by lowland topography, and the area selected generally shares a similar gradient. Swamps are transformed into polders by enclosing the designated site with an earthen embankment in a semi-circular shape that runs parallel to the riverine arm of the sea (Fig. 3). The embankment or dike functions to prevent the intrusion of saline water and loss of rainwater impounded within the perimeter. Dike construction involves digging the soil inland from the embankment, which establishes the location of the principal drainage canal. The embankment, constructed of ample height and width to block the force of marine tidal surges, often reaches more than a meter's height and span, and frequently stretches over several kilometers. A series of lower dikes are then constructed inland and perpendicular to the embankment, which divide the perimeter into individual rice plots.

Once tidal flows are blocked, the network of drainage ditches is completed. Water control is achieved by means of a system of secondary sluices that empty into the drainage canals for evacuation at low tide into the river channel through the main embankment sluice. The main sluice is constructed from hollowed tree trunks and covered with a board positioned to act as a valve. Under the pressure of rainfall and sea tides, the sluice gate opens and closes automatically. The valves remain closed against outside seaward pressure during high tides but open at low tides from the force of captured rainwater.

Fig. 3. Tidal Rice System, Senegal.

Once the perimeter is enclosed and the drainage system in place, land clearance occurs. Mangroves outside the perimeter are left in place to reduce tidal force and the overflow of brackish water onto rice plots (Fig. 3). The next step involves plot desalination and the removal of mangroves within the reclaimed perimeter. Embankment construction severely restricts entry of brackish water, thereby initiating mangrove death. The process of impounding rainwater for field desalination may take from two to eight rainy seasons during which mangroves have rotted and the plot cleared of debris.

Work then gets underway on the individual rice plots, which are ridged—a technique that minimizes the accretion of salts from capillary action. The cultivation cycle begins during the dry season when men prepare plot ridges with long handled, flat bladed shovels (Diola: *kay-endo*), well adapted to the task of turning the heavy clay soils. The action of using the *kayendo* aerates the soils, overturns weeds, and assists in the plot's desalination. Residual plant matter is placed in the troughs created

between the ridges, where it is left to compost. With the onset of rains women establish rice nurseries near the village. Once the rains complete the washing of salts from the soil, a few seedlings are tested to ensure the plot is adequately desalinated. The seedlings are transplanted atop the ridges and the rice field reverts to rainfed cultivation. Harvest generally occurs about four months later, the crop ripening after the rains cease from moisture stored in the soil.

African soil and water management practices in tidal saline systems involve adjusting rice cultivation to an environment at risk from saltwater encroachment and soil acidification. High yields are sustained without fallowing or crop rotation due to steady deposits of alluvium rich in organic matter. While alluvial deposition is less in those swamps only occasionally swept by river tides, the production zone is nonetheless prized for its value as dry season pasture. When the rice harvest is completed, Fulani herders head cattle into the swamp to graze rice residues. Straw availability is ample because rice is usually cut with a small knife, which severs the plant near its grain clusters while leaving the stalks in the field. The process reduces the weight and bulk of the harvest and facilitates transporting paddy by head to villages. When dry season grazing is completed, the animal manure is spread over the plots to enhance soil fertility.

Another critical agronomic tool developed by West African rice farmers is the use of field flooding for weed control. Tidal inflow depresses the growth of weeds whose seeds, unlike the rice plant, cannot germinate under anaerobic conditions (Grist, 1968). Weed populations are particularly suppressed in the tidal saline production system where brackish water dominates during most months of the year. Although river tides provide the supplementary water reserves critical for production, their role in weed reduction is equally important for high yields.

Each of the indigenous West African rice systems presents differing labor demands, harvest dates, weeding and fertility practices. A sophisticated understanding of micro-environmental diversity, moisture regimes, soil properties, saltwater movements, and tidal flows shaped a food system that has enhanced human survival in West Africa for millennia.

Rice Cultivation in South Carolina. This section provides an historical overview of the spatial changes in rice cultivation within South Carolina as the economy became harnessed to rice exports. Emphasis is on the

colonial period when experimentation with rice-growing got underway and production shifted through distinct micro-environments. Although South Carolina remained a rice producer until the early 1900s, the cultivation systems analogous to those of West Africa were already sown by 1738. The initial phase of rice cultivation, from the 1670s to the turn of the century, proved the crop's viability for export and resulted in an accelerated demand for West African slaves. By the 1720s, pluvial rice was being de-emphasized in favor of phreatic rice, cultivated in inland swamps, where drainage and field irrigation techniques improved yields. While the phreatic system dominated throughout most of the colonial period, by the Revolutionary War rice planting was steadily shifting to fluxial production with the refinement of floodplain management techniques and planting methods along riverine swamps. Fluxial, or tidewater, rice underwrote South Carolina's economic prosperity during the ante-bellum period.

Rice importation into South Carolina, possibly for cultivation, is first documented in 1672, although the English Lord Proprietors charged with encouraging migration had discussed its potential along with other exotic crops prior to settlement (Wood 1974b, p. 27). By 1690, rice planting in the colony had begun in earnest with numerous locales cultivated (Wood, 1974b, p. 57). Planters of English and French Huguenot descent were unfamiliar with the water control techniques and agronomic skills for rice growing even as late as 1704 when one English visitor noted: "... [Europeans] being unacquainted with the manner of cultivating rice" (Wood, 1974b, p. 56). Pluvial rice dominated during this initial plantation period for its complementarity with livestock which was being raised for salted beef exports. Rice was grown in rotation with cattle, following principles similar to the existing system in West Africa (Gray, 1958; Rodney, 1970; Drayton, 1972; Wood, 1974b, pp. 45, 131; Nairne, 1989; Norris, 1989; Otto, 1989, pp. 35-37).

Slave labor underpinned the emergent agro-pastoral economy. Slaves cleared the forests, extracted pitch, tar and resin from pines, herded cattle, and grew the subsistence crops (Otto, 1989; Wood, 1974a, p. 162). The remaining decade of the 17th century established the viability of rice as a cash crop but its areal expansion depended on greater numbers of slaves. Intensified extraction of forest and animal products (naval stores, deerskins, and salted beef) provided the critical capital for slave imports whose numbers increased dramatically from 3,000 in 1703 to about 11,800 in 1720 and nearly 41,000 in 1745 (Craven, 1949; Clowse,

1971; Wood, 1974b; Ver Steeg, 1975; McCurry, 1988; Coclanis, 1989; Otto, 1989; Silver, 1990).

The swelling slave population coincided with a shift in rice cultivation to the phreatic system (Wood, 1974b, pp. 57–58; Kovacik and Winberry, 1987, p. 73). The planting of low-lying depressions enabled rice growers to take advantage of supplemental water resources from moisture-holding soils and high water tables, which led to improved yields. Water control proved so critical to yield increases that reservoirs were frequently constructed to store water for supplemental irrigation during mid-season dry spells (Clowse, 1971, pp. 126–132).

The inland swamp production zone and the techniques developed for trapping water closely approximated those of the West African phreatic system. African slaves constructed embankments, bunds, sluices, and gates to capture water for plot saturation as well as weed control. The system was sometimes elaborated by directing a canal from a reservoir to the rice field, which fed into a secondary canal that emptied with gravity flow from the lower bank through a trunk into an adjacent creek. This refinement facilitated greater mastery of water, which could be drawn or drained according to crop requirements (Heyward, 1937; Hilliard, 1978; Porcher, 1987; Whitten, 1982).

Two variations of the West African phreatic rice system also appeared in South Carolina: one system permitted production in saline marshes while the other involved manipulating subterranean springs for a steady influx of water. The first type developed in salt marshes near the ocean. Although saltwater kept marshes free of woody vegetation and thus meant less labor for land clearance, cultivation required plot desalination. This was accomplished by constructing an embankment across the lower end of the swamp to block salt water entry (Hawley, 1949). A second embankment on higher ground formed the lower lip of a rainfed, gravity flow reservoir which captured stream water for desalination and irrigation. This variant of the phreatic system functioned along the Cooper River where “[t]he 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” (Irving, 1969, p. 154).⁴

Swamps located astride springs served as yet another micro-environment for phreatic rice production. Springs that arose in areas of high water tables delivered a steady flow to rice plots. Although limited in areal extent by the number of springs in the South Carolina Lowcoun-

try, such swamps were prized for rice production and continued to be cultivated throughout the ante-bellum period when cultivation had shifted to the fluxial system. Ravenel (1859, p. 29) provided a description of this system in Berkeley County, South Carolina, on the eve of 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 Acqueduct, to be used on the Rice-Fields of Wantoot Plantation."

The phreatic cultivation method that characterized colonial rice production presented numerous advantages over upland rice. Inland swamps relied on bottom mud and decaying organic matter for fertility and thus could be cultivated continuously. Enclosing the swamp with earthen bunds and embankments provided a method to trap water for plot moisture requirements. Constructing a system of sluices and gates enabled the control of water inflow and outflow for field flooding and weed suppression—a major labor-demanding activity in rice cultivation (Heyward, 1937; Hilliard, 1978). In his review of early colonial references to rice, Gray (1958, p. 281) underscored the significance of weeding and its associated labor demands for phreatic and subsequently, fluxial cultivation: "Only two flowings were employed [phreatic] as contrasted with the later period when systematic flowings [fluxial] came to be largely employed for destroying weeds, a process which is said to have doubled the average area cultivated per laborer . . .".

Despite its advantages over the pluvial system, phreatic rice production faced two major constraints: i) the limited areal availability of inland swamps; and ii) fluctuations within precipitation regimes, which in dry years could lead to inadequate water storage and reduced crop yields, but in other years might result in severe end-of-season rainstorms (freshets), swamp overflow, and loss of the rice crop (Allston, 1854; Heyward, 1937; Hilliard, 1978). Despite such drawbacks, the phreatic system remained the dominant planting method until the 1750s with the growing emphasis on tidal rice cultivation along the coast (Rogers, 1970, p. 332).

The economic prominence of South Carolina was built upon the fluxial rice system which flourished from the ante-bellum period until the demise of cultivation in the early 20th century. Fluxial cultivation occurred along rivers located within 20 miles of the coast and utilized tidal flow to irrigate and drain floodplain swamps. Figure 4 presents the major rivers sown to tidewater rice in South Carolina during this period.

The techniques and method for planting rice with tidal flow became

Fig. 4. Tidewater Rice Cultivation, South Carolina.

evident during the massive influx of West African slaves into South Carolina in the first decades of the 18th century. A notice of land sale in 1738 by William Swinton of Winyah Bay near Georgetown, which became South Carolina's largest rice-producing district, provides the first documented reference to tidewater production: "... that each 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."⁵ This statement establishes that tidewater cultivation existed in the colony by the 1730s and that planters had become aware of the value of tidal flow for overcoming drought stress. The emphasis on tidewater rice depended on large numbers of slaves to clear the cypress and tupelo gum swamps but, even more significantly, the knowledge of tidal dynamics for crop irrigation and the appropriate techniques for floodwater control (Ruffin, 1847; Richards, 1859; Ferster, 1860; Doar, 1970; Hilliard, 1975; Clifton, 1985; Silver, 1990). The vast expansion in floodplain cultivation during the second half of the 18th century increased the demand for slaves, their numbers nearly doubling from 39,000 to 75,000 between 1750–1770 (Otto, 1989, p. 41).

The principles utilized to convert South Carolina's tidal swamps to rice paddies corresponded closely with those developed in the West African fluxial system: cultivation involved considerable knowledge of fresh and saltwater dynamics. Because a three-to-five foot tidal pitch was necessary for freshwater flooding and drainage, a point upriver would be reached of diminished tidal amplitude above which rice fields could not be constructed (Wilms, 1972; Hilliard, 1978, p. 101). How close to the ocean rice could be grown depended on even more complex hydrological conditions, viz., differences in freshwater availability between rivers of coastal or piedmont origin. Rivers that are arms of the sea, like the Cooper River, must reach farther inland for freshwater. Rivers that originate in the piedmont, however, like the Santee River, discharge so much water that a layer of freshwater rides on top of the heavier saltwater for considerable distances downstream (Fig. 4). When this freshwater layer was of sufficient thickness, it could be extracted for rice field irrigation nearly to the sea (Doar, 1970; Heyward, 1937; Pringle, 1961).⁶ Tidewater cultivation along these two types of rivers consequently became feasible because skilled observation of tidal dynamics and saline-freshwater interactions reduced cropping risks.

Preparation of a tidal river system for rice cultivation followed

principles discussed above in West African fluxial production. Figure 5 (Hilliard, 1975), which presents the sequence of activities in floodplain conversion to rice paddy, illustrates the remarkable similarity to the analogous West African system represented in Figure 3. Fields were divided and embanked, with plots averaging between 10–30 acres. An embankment of sufficient height to prevent tidal spillover was constructed along the river as well as through the swamp area for additional water control. The earth removed in the process resulted in an adjoining canal, employed to receive or drain water from the fields. A series of trunks (20–30 feet long) operated as valves to allow water flow between the cultivated area and the river. At each end of the trunk a hanging gate was positioned to regulate water entry and evacuation (Doar, 1970, pp. 7–15; Clifton, 1985, p. 7; Whitten, 1982, pp. 9–10; Hilliard, 1975, pp. 58–60).

Like the West African tidal saline system, South Carolina tidewater production depended upon diurnal variation in marine tides and its ef-

Fig. 5. Tidal Swamp Conversion, South Carolina. Source: Hilliard 1975.

fect on estuary and river water levels. When the tide lifted freshwater in the river above the field level and irrigation desired, the trunk gate on the river side was raised. Water flowed through the river and field gates onto the fields. The river gate was raised repeatedly with successive high tides until fields were adequately flooded. Field drainage occurred through a reversal of this process by raising the field gate and lowering the river gate so that water could be evacuated with low tides into a canal or the river (Kovacik and Winberry, 1987, p. 73).

The use of tides for rice cultivation flooded the crop when water was needed, permitted drainage when fields were excessively submerged, and enabled immersion for weed and insect control. This knowledge improved rice yields while enabling an expansion of cultivation in South Carolina over 150,000 acres of swamps and tidal marshes. Tidewater cultivation greatly reduced labor demands over previous systems, with a slave able to manage five acres instead of the two typically planted in phreatic rice (Allston, 1854; Clifton, 1981, p. 275; Whitten, 1982).

During the first half of the 18th century rice cultivation shifted through three distinct micro-environments in South Carolina. This resulted from the elaboration of agronomic principles and techniques for field flooding. By the American Revolution the colony's economic prominence was anchored to tidewater cultivation. The appearance and rapid diffusion of the techniques and infrastructure for water control and their close correspondence to West African systems suggests that slaves may indeed have contributed more than unskilled labor to the creation of one of the New World's most prosperous plantation economies.

Conclusion. The view of Africans as mere hands and bodies with nothing more to contribute than brute physical labor dominated historiography of the South Carolina rice economy until Wood's (1974a, 1974b) pioneering research. By directing attention to the fact that many slaves possessed previous knowledge of rice cultivation, historical scholarship opened up the possibility for technological transfer of rice by West African bondsmen to South Carolina. This paper's focus on the spatial relations underlying cultivation in two regions linked by the slave trade and rice illuminates the close correspondence in micro-environments planted, types of water resources used for irrigation, and engineering devices developed for regulating field flooding. The replication of parallel systems in colonial South Carolina lends support to the hypothesis that Africans may have created the knowledge base for the evolution of the

rice plantation economy of the South. If additional evidence supports the research presented in this paper, then South Carolina's "unlikely innovators" (Earle, 1992, p. 269) provide yet another example to illustrate that science and technology were not solely the achievements of Europeans but also shared by the non-Western peoples whom they dominated following 1492 (Adas, 1989; Blaut, 1992; Carney, in press).

NOTES

- ¹ The authors would like to acknowledge the thoughtful comments provided by the journal's reviewers on an earlier draft.
- ² Estimates on total acreage in tidal rice are also derived from Porcher's analysis of aerial photographs in South Carolina.
- ³ The emphasis of this paper is on the types of rice production systems found in both West Africa and South Carolina, which can be differentiated by distinct water regimes. The three systems that operated in South Carolina and Georgia represent the major water regimes sown to rice in West Africa but only a portion of the micro-environments planted.
- ⁴ The remains of similar systems can be seen at Drayton Hall on the Ashley River and behind Murphy Island in the Santee Delta, where an extensive salt marsh exists within easy reach of freshwater.
- ⁵ The land sale was advertised on January 19, 1738, in the *South Carolina Gazette*.
- ⁶ As the similar system in West Africa, reliance on the sharp horizontal discontinuity between fresh and saltwater in tidewater cultivation was not without risk. End of the season hurricanes periodically drove saltwater beyond its normal upriver bounds which resulted in crop loss (Heyward, 1937; Pringle, 1961; Doar, 1970).

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