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Forced migration, environmental change and woodfuel issues in the Senegal River Valley

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Summary

There is increasing international concern about the environmental impacts of refugees on host areas, with governments calling for compensation for environmental damage, particularly concerning the loss of woodland resources as a result of demand for wood for fuel. In addition to an obvious increase in the population of host areas, concern about refugees' woodfuel-use centres on the notion that they are 'exceptional resource degraders'. Since they view their stay as temporary, it is argued, they therefore do not have any incentive to use resources in a way that is sustainable in the long-term. This study examined refugee migration to the middle valley of the Senegal River, and compared woodfuel use by refugee and local populations. Drawing on a household survey and direct measurement of woodfuel use, little or no evidence is found to support the expectation that refugees use more wood for fuel than local people, or that they are more destructive in their collection or use of wood. This is important since it suggests that policy measures developed to reduce what is perceived as excess demand by refugees, notably through the introduction of fuel-efficient stoves, are unlikely to be successful. Reforestation schemes have been relatively unsuccessful in addressing supply or demand for wood.

Keywords: refugees, environmental change, woodfuel, Senegal, deforestation, desertification

Introduction

Wood is the primary source of energy for the vast majority of households in much of Africa (Leach & Mearns 1988), and as such, pressure on woodfuel resources is a matter of great significance for the livelihoods of many Africans. Much has been written on the woodfuel 'gap' or 'crisis' in the last two decades since Eckholm's (1975) description of the 'other energy crisis', with some authors arguing that woodfuel use significantly contributes to deforestation and desertification (French 1986), whilst others have questioned whether a problem exists at all, at least in terms of rural woodfuel use (Dewees 1989; Mercer & Soussan 1992). Certainly, the extent of pressure on woodfuel resources depends on a number of factors, including diet, stove technology, cooking habits, preference for open fires or particular kinds of stove, the nature of wood used, its origin, quality and availability, and availability of alternative fuels (Morgan & Moss 1981). In addition, wood is not used simply for cooking, but fulfils a multitude of other functions from providing light and heat when burnt, to providing the material for construction of houses, and the manufacture of a range of wood-based products, such that the woodfuel question is not simply one of providing fuel for stoves. For example, in the case of the middle valley of the Senegal River, which forms the focus of this article, significant quantities of brushwood are also used as fencing for fields, to protect them from livestock, and these need to be renewed each year. Assessing the independent effect of these and other demands on woodfuel is not a simple task.

One significant undercurrent of the literature on the woodfuel 'gap' is the notion that growth in population is a major contributing factor in increasing demand for wood products, and it is in this sense that there has recently been concern about woodfuel issues amongst academics and practitioners concerned with refugee issues (Hoerz 1995*a*; Jacobsen 1997). Although the rising number of refugees worldwide does not necessarily imply any global increase in the pressure on woodfuel resources, the concentration of refugees into certain areas, which are often environmentally marginal, does increase the potential for localized pressure. In turn, evidence of deforestation has been cited and stressed in a number of studies of refugee-affected areas (Allan 1987), including a number of recent 'environmental assessments' of refugee assistance programmes (Caminada 1992; CARE/ODA 1994; Ketel 1994*a*, *b*), even though much of this evidence requires extreme caution in interpretation (Black 1994*a*).

There are particular reasons why there might be cause for concern about the impact of refugees specifically on deforestation through their search for woodfuel resources. For example, Hoerz (1995*b*, p. 33) argues that although it is now accepted that 'most rural people do not cut live trees down for firewood', nonetheless, in refugee situations, 'the Malthusian "population shock" takes place, leaving no time to balance population densities and carrying capacities in terms of household fuel or to adjust cooking and eating pat-

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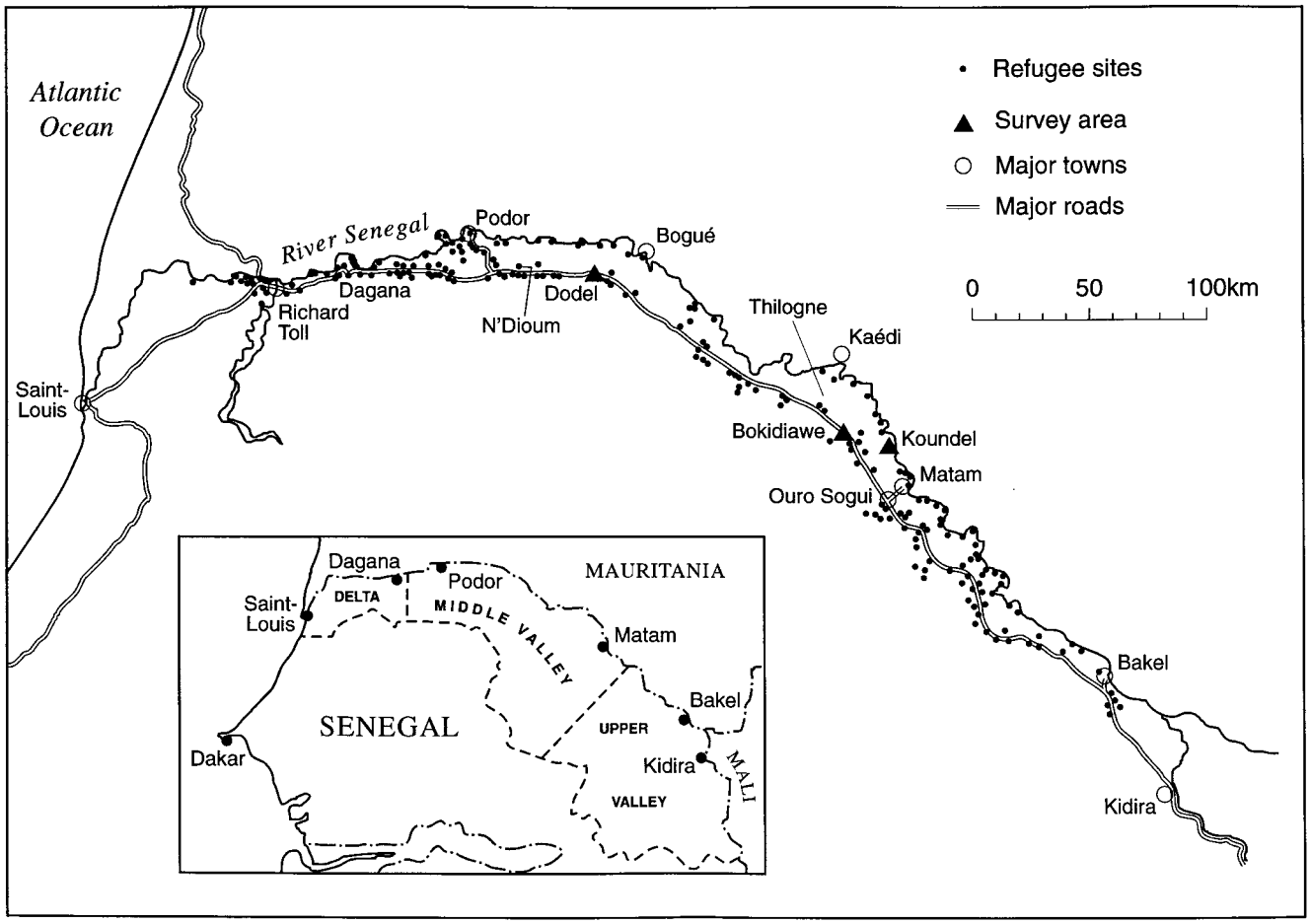

Figure 1 The Senegal River Valley: location of field sites. Data provided by the United Nations High Commissioner for Refugees, Saint-Louis Sub-Office.

terns to scarcities.' There has been much acceptance of the hypothesis of Leach (1992, p. 44) that refugees are 'exceptional resource degraders', who use wood and other resources without regard to long-term sustainability because they view their stay as temporary (cf. United Nations High Commissioner for Refugees (UNHCR) 1995, p. 167), even though Leach herself found only 'occasional instances' of this behaviour. In turn, a recent edition of the *Oxfam Handbook of Development and Relief* stated that, whilst the notion of an imminent 'woodfuel crisis' is 'largely discredited' (Oxfam 1995 p. 583), the risk of a 'deforestation crisis' in the medium term does still exist, and requires attention. Interestingly, with regard to refugee camps, Lamont-Gregory (1995) makes precisely the reverse point, arguing that provision of fuel to refugees in the short-term is a necessary and life-saving intervention for a range of health and nutrition-related reasons.

These issues are considered further, after a brief overview of the nature of refugee flight to the Senegal River valley, their pattern of settlement, and existing environmental issues within the region.

Refugee migration to the Senegal River valley

In April 1989, an estimated 60 000 Mauritanian refugees fled to Senegal, along with as many as 70 000 Senegalese citizens who were living in Mauritania at the time, after violent clashes between farmers and pastoralists in the Bakel region of the Upper Valley of the Senegal River (Kharoufi 1994). The conflict had broader origins, with discrimination against the black population of Mauritania, and tensions between Mauritania and Senegal, stretching back over decades, as well as more recent political tensions surrounding the development of irrigation in the valley (Horowitz 1991). Moreover, population displacement in 1989 affected the whole country, and included an exchange of peoples: thus many thousand Mauritanians, some living in the river valley, but mostly in the Dakar region, were deported by Senegal to Mauritania at the time, whilst a number of the Senegalese citizens forced to return resettled in the major towns of Dakar and Saint-Louis. Nonetheless, and despite a long history of population migration in the region (Lericollais 1975; Adams 1977; Condé & Diagne 1986), an immediate outcome of the events of 1989 was a significant increase in the population of the left bank of the Senegal River Valley, namely the Senegalese side.

Whilst the Senegalese 'repatriates' were largely reintegrated into local communities, the refugees were placed in over 250 camps or 'sites' along the length of the river valley from Dagana to Bakel (Fig. 1). In this way, the refugees were dispersed across a relatively wide area, and despite the establishment of a small number of larger camps, such as those at N'Dioum and Dodel in Podor *département*, none of these individual sites received more than 2500 people (Sevestre *et al*. 1989). In general, sites were established on the outskirts of existing towns or villages, by agreement with local authorities, although some sites were also located away from existing settlements, in particular along the main N2 national road. The dispersal of the refugees helped to ensure that localized pressure on land and other natural resources was reduced, although the nature of competition and/or co-operation between refugees and local villagers varied from site to site.

Within the two départements of Matam and Podor, which form the focus of this paper, around 47 000 refugees were settled, or nearly 80% of the total Mauritanian refugee influx (Mbaye *et al*. 1994). Thus in the space of one year, 1989, this zone received an influx that amounted to a 12% increase in the existing population of 374 403 (1988), not counting Senegalese 'repatriates' (RDS 1992). Despite its dispersal, this new population sought both land and access to other natural resources in a region already suffering from the severe effects of drought, and with a highly vulnerable environmental status.

Assisted initially by local populations, the international community became rapidly involved in providing assistance, and by December 1989, the United Nations High Commissioner for Refugees (UNHCR), the lead agency involved, had already begun to investigate potential programmes to stimulate economic activity and ultimately self-reliance for the refugee population (Sevestre *et al*. 1989; Thiadens 1992). As elsewhere in the world, the main element of international assistance was the supply of food rations, including grain (usually sorghum or millet), beans, sugar, salt, cooking oil and powdered milk, supplied by the World Food Programme. From 1992, the size of the rations was progressively reduced, with the quantity of grain supplied declining by half between 1991–93, from 500 to 250 g person^{-1}day^{-1}, as self-sufficiency of the refugees began to be promoted as a goal of UNHCR policy (Thiadens 1992).

The dispersal of the refugee population in 1989, and the welcome and assistance offered by local villagers, who were often directly related to the refugees through lineage groups, and had, in many cases, also lost land, property or family members in Mauritania, went some way to reducing the potential impact of the new arrivals in terms of generating conflict over the natural resources of the left bank of the valley. Nonetheless, the potential for pressure on these natural resources remained great, particularly given the precarious state of the natural environment of the valley, which is considered below.

Forest resources and deforestation in the Senegal River Valley

The forests of the middle valley of the Senegal River have for a long time been exploited for wood for construction, fuel and charcoal, as well as for other purposes. For example, *Acacia nilotica* produces firewood and charcoal of excellent quality, as well as gum arabic, and is the most sought and preferred tree species, whilst *Acacia albida* produces leaf in the dry season and is thus valued for fodder (von Maydell 1992). In the case of *Acacia nilotica*, natural regeneration is enhanced by temporary flooding of the forest which provides the necessary conditions for seeds to germinate. However, one important cause of deforestation in recent years, particularly in the last ten years, has been the diminution or absence of flooding, as a result of the construction of dams at Manantali (in Mali) and Diani (in the delta) and the regulation of the flow of the Senegal River. This process, coupled with the expansion in irrigation schemes (Crousse *et al*. 1991; Horowitz 1991) and overgrazing by livestock, may have seriously compromised the future formation of forests. Toussaint *et al*. (1994) argue that the distribution of tree population by age resembles an inverse pyramid, indicative of a population on the verge of extinction.

An additional important element of deforestation in the middle valley involves possible links between this process and medium-term climatic change (van Lavieren & van Wetten 1990). Successive droughts during the 1970s and 1980s, which affected the whole of the Sahel region, were also characteristic of the middle valley, and these have led some observers to argue that the region is undergoing 'desertification', which may be seen either as a natural process, or one which is stimulated by human activity and especially the impact on climate of changes in vegetation cover and other surface characteristics (Agnew 1995).

According to Betlem (1988), between 1954 and 1986 the area of forest reserves in the département of Podor, which has the largest area of such reserves, decreased by 70%, with degradation proceeding at the same speed both inside and outside of the *forêt classée* (statutory forest reserve; Betlem 1988). Excessive exploitation of forests has also been stimulated by the increase in demand for wood and charcoal in the urban centres, particularly the cities of Saint-Louis, Thiès and Dakar. In 1980, the département of Podor furnished 20% of the nationally-controlled production of firewood and more than 25% of charcoal (Daffe *et al*. 1991). In addition, overgrazing and the shortage of pastures due to drought has also in recent years led to a shift into the floodplain of the river itself, where pasture and forage are more abundant, especially during the dry season (van Lavieren & van Wetten 1990). As the state of the forests in the floodplain has deteriorated, there has been some species substitution. For example, *Acacia nilotica*, that existed in low-lying areas which were once severely flooded, are being replaced by *Acacia raddiana* and afterwards by *Balanites aegyptiaca* when dry conditions increase (Toussaint *et al*. 1994).

The main purpose of the empirical study which follows was to consider the proposition that refugees are 'exceptional resource degraders' on the basis of field evidence. The study sought to determine whether there were identifiable differences between refugee and local populations in patterns of resource use, which might raise concerns about environmental sustainability. In particular, the hypothesis that refugees are 'exceptional resource degraders' would lead us to expect that refugees use more woodfuel (and more natural resources in general) than locals, both because of their poverty, and because they do not have such a stake in the longer-term sustainability of forest resources. The type of fuel used by the two groups might also be expected to differ, with locals more willing to adapt by using different types (species) of wood, or different fuels, in the face of shortages of preferred species. The study also considered the political, economic and social context in which refugee and local populations gain access to woodfuel and other resources, since this is seen as crucial in influencing patterns of resource-use behaviour. Finally, the paper appraises two measures that are currently advocated to address the problem of deforestation in refugee-affected areas, namely the introduction of fuel-efficient stoves, and reforestation schemes, to consider whether there are differential levels of participation in such remedial measures amongst refugee and local populations.

Methods

Study area

The middle valley of the Senegal River lies at the heart of the Sahel zone, in which there has long been concern about the relationships between population growth, deforestation and land degradation. Forests are an important resource in the valley, with the principal formation in the floodplain (known as the *walo*) being forests of *Acacia nilotica* (Betlem 1988). These are closely linked with the hydromorphic conditions (the height of floods) and toposequence (flood plain, *levées*) in the valley. They make up a major part of the statutory forest reserves (forêts classés) in the region, and are managed by the state forestry service (*Direction des Eaux et Forêts*). Betlem (1988) has classified the vegetation into broad groups: *Acacia nilotica*, *Acacia albida* and *Balanites aegyptiaca*, which are trees, represent the largest group; *Acacia raddiana*, *Acacia seyal*, *Bauhinia rufescens*, *Calatropis procera* and *Ziziphus mauritania*, which are trees or shrubs, are readily encountered in the valley; and *Acacia sieberiana*, *Mitragyna inermis*, *Tamarindus indica* and *Ziziphus mucronata*, which occur sporadically along the edge of the river and its tributaries.

In addition to the forests which form the main vegetation formation in the walo, the area immediately outside the floodplain (known as the *diéri*) consists largely of an open formation of the savanna and steppe shrubs and trees type, with the typical herbaceous cover dominated by *Cenchrus biflorus* and *Aristida* spp. The dominant woody species are *Acacia raddiana*, *Balanites aegyptiaca*, *Boscia senegalensis* and *Calatropis procera*. There are also *Acacia senegal*, *Acacia seyal*, *Adansonia digitata*, *Combretum glutinosum*, *Euphorbia balsamifera*, *Acacia nilotica*, *Ziziphus mauritania*, *Bauhinia rufescens* and *Acacia albida*. According to Betlem (1988), the area of land in the diéri covered by woody species rarely exceeds 15%, most often it is less than 5%. The herbaceous vegetation constitutes a major source of forage with woody plants providing additional forage particularly during the dry season.

Survey

Empirical material presented here is based on a household survey conducted in the middle valley in April–May 1995, comprising of a random sample of 30 households in the villages of Bokidiawé, 30 households in the village of Koundel, and 60 households in the village of Dodel (Fig. 1), with an equal number of refugee and Senegalese respondents in each village. The survey collected information on household composition, farming practices, other economic activities, use of natural resources, and attitudes towards and participation in various resource-using and resource-protecting activities. Specific information was collected on broad patterns of use of different fuels, preferences for use of these fuels, and modes of access. Interviews were usually held with the head of household, although wherever possible, other household members were encouraged to be present and contribute to discussion. To facilitate this, interviews were usually held at the home of the respondent. Interviews remained open-ended and exploratory, and were conducted through interpreters from French to *pulaar*, or in the case of some of the residents of Bokidiawé, to *soninké*.

In addition, a number of other methods were used in order to generate a range of information of relevance to local resource-use practices. Simultaneous with the household survey, a separate survey of the woodfuel use of women over a 2–3 week period was conducted with a sample of 30 women in two refugee sites (Elévage, Dar-Salaam) and 30 Senegalese women in the village of Thiambé, all in the vicinity of the town of Ourosogui (Matam département). This survey measured the total amount of wood and other fuels consumed each day, by asking respondents to set aside each morning the wood or other fuels they would use for cooking that day, and cross-checking the following morning whether this amount had been used. Also measured were the type (species) of wood used, the provenance of the wood, and the number of meals cooked each day. For each respondent, additional household information was collected concerning the cooking technology used, and limited information on the household economy for cross-checking with the household survey. After excluding several respondents for whom data recording was judged unreliable (because of lack of consistent co-operation with the researcher), 52 respondents were finally selected for specific comparison of woodfuel consumption rates. For this group, after discounting days on which fuels other than wood were used for cooking, total consumption of woodfuel was calculated for a continuous 14-day period.

Table 1 Use of woodfuel by sample refugee and local households in Bokidiawé, Dodel and Koundel.* Significant difference $p < 0.05$; ** significant difference $p < 0.01$.

	Refugees (No.)	*Locals (No.)*	χ^2
Households collecting wood:			
Regularly	40	28	4.89*
Headload	31	17	6.81**
Cartload	16	20	0.64
Total	47	37	3.97*
Households buying wood:			
Regularly	37	40	0.33
Per day	30	30	0.00
Per cart	17	11	1.68
Total	50	45	1.26
Total households sampled	60	60	

Table 2 Use of alternative fuels by sample refugee and local households in Bokidiawé, Dodel and Koundel. * Significant difference $p < 0.05$; ** significant difference $p < 0.01$.

	Refugee (No.)	*Locals (No.)*	χ^2
Households using other fuels:			
Animal dung	21	4	14.60**
Charcoal	11	12	0.05
Straw / maize cobs	1	1	0.00
Gas	2	8	3.93*
Total households sampled	60	60	

Supplementary information was also derived from interviews with key informants amongst the refugee and local communities, and with government officials and representatives of assistance agencies, and from collation of available statistical and other material in unpublished format from a range of local organizations. For example, in each village, discussions were held with village elders, and groups of women on issues such as preferred species and fuels for cooking, against which patterns of actual resource use by surveyed households could be assessed; whilst interviews were also held with members of local resource management committees (*Comités de gestion*) on vegetation change and particular ecological problems faced in the village.

Results

All of the refugee and local households interviewed in the household survey used wood for at least part of their cooking requirements. In turn, a majority of both groups both bought some firewood and collected some themselves (Table 1). Overall, the survey showed no significant difference between the two groups in terms of their likelihood to buy wood; however, a significantly greater number of refugees were found to collect firewood on a regular basis, with those doing so more likely to do this on a day-to-day basis according to requirements, rather than in bulk using a donkey and cart.

Table 3 Ownership of livestock by sample refugee and local households in Bokidiawé, Dodel and Koundel. ** Significant difference $p < 0.01$.

	Refugees (No.)	*Locals (No.)*	χ^2
Households owning:			
Any livestock	78	72	0.64
Cattle	15	12	0.38
>10 sheep or goats	39	10	21.57**
Households practising transhumance	22	4	13.98**
Total households sampled	120	120	

Table 4 Use of specific tree species by sample refugee and local households in Bokidiawé, Dodel and Koundel. ** Significant difference $p < 0.01$.

Species used (by village)	*Refugees (No. households)*	*Local (No. households)*	χ^2
Balanites aegyptiaca	42	38	0.60
Acacia nilotica	30	51	16.75**
Ziziphus mauritania	14	19	1.05
Acacia ehrenbergia	15	14	0.05
Calatropis procera	10	0	10.91**
Pterocarpus lucens	12	13	0.05
Mitragyna inermis	3	6	1.08
Total households sampled	60	60	

There were significant differences in the use of two alternative fuels to wood, namely animal dung and gas, although for two other fuels, charcoal was used roughly equally by the two groups, whilst straw was hardly used at all by either group (Table 2). Animal dung is generally regarded as an inferior fuel due to the low heat obtained and its smell, whilst straw is seen as a fuel of last resort if other fuels are largely unobtainable. In contrast, the use of calor gas for cooking is expensive, making it an option only for wealthier households. It is worth noting that refugees had access to larger quantities of animal dung than locals, with a significantly higher proportion of households interviewed owning more than 10 sheep or goats, and / or practising transhumance (Table 3).

The question of access to preferred fuels is also illustrated by the use of different tree species by refugees and local people (Table 4). Discussions held at village level suggested that preferred species varied slightly for the three villages studied: in all three villages, *Acacia nilotica* was cited as a preferred species by most respondents, along with *Balanites aegyptiaca* in the case of Koundel and Dodel, and *Pterocarpus lucens* in Bokidiawé. However, whilst the latter two species were used by roughly equal numbers of refugee and local households in each of the villages studied, across the three villages, a significantly higher proportion of local households reported using *Acacia nilotica* (Table 4), despite the fact that this species was widely recognized as being under pressure. In contrast, a third of refugee households (all in Dodel) reported using *Calatropis procera*, a relatively abundant shrub

on the diéri, but which many local respondents commented they would never use (and indeed which no local household did use), since it has poor burning qualities, burning too quickly and producing a lot of smoke. Meanwhile, another species cited by both populations as being a good, but increasingly rare source of woodfuel, *Mitragyna inermis*, was used by twice as many locals than refugees (all of them resident in Koundel), although the total numbers using it were too small to detect any statistically-significant difference.

Little difference was found in terms of respect for rules on cutting trees, or involvement in the 'replanting' of trees. Most household heads interviewed appeared unaware of any laws or customary rules prohibiting the cutting of specific trees. However, in Koundel, for example, two trees mentioned by several households which did fall into this category, namely *Acacia albida* and *Piliostigma reticulatum*, were only reported as being used by two (refugee) households. A total of 49 out of 60 refugees and 51 out of 60 locals reported that they had planted trees, although the majority of these had planted only a small number of trees, mainly the ubiquitous 'neem' (*Azadirachta indica*), in household compounds for shade, or had merely participated in state or non-governmental organization (NGO)-sponsored planting around irrigated perimeters. Finally, no refugee or local households reported breaking the current ban on production of charcoal, with most attributing this activity, where it occurred, to outsiders.

Overall, data obtained from the household survey suggest that local households are either more able (through greater access or money), or more willing to use higher-quality tree species for woodfuel, despite the fact that such species are sometimes regarded as in need of protection. Local households were also found to be twice as likely to be aware of a decline in the overall availability of wood over recent years, however, with most citing drought as the reason for this. Only four households commented that the decline was related to the presence of the refugees. Two particular aspects of this decreasing availability were highlighted by respondents during interviews and in village-level discussions. Respondents noted the reduction of particular species in the walo, notably *Acacia nilotica* and *Mitragyna inermis*; and also, an increase in the distance it was necessary to travel within the diéri to find suitable dead wood for collection. Responses to woodfuel scarcity also varied, with 65% of local households interviewed having switched at least partly to using a fuel-efficient stove, mostly in the last two to three years, compared to 47% of refugee households.

The woodfuel survey showed that, excluding days on which other fuels, notably dung, were burnt, there was no significant difference ($p > 0.05$) between average consumption of woodfuel by refugee and local households, with refugee and local women consuming a mean of 0.90 and 0.85 kg person^{-1}day^{-1} respectively (Table 5). However, if the use of other fuels is taken into account, it becomes clear that, if anything, it was local women who used more wood. For example, amongst this sample population, six out of 28 refugee women regularly used dung as a fuel during the dry season, whilst a further two relied mainly on wood chippings produced as a by-product of wood sculpting by the husband of one of the women. In contrast, none of the Senegalese women used dung at all. Also, unlike the household survey, none of the refugee women who participated in the woodfuel survey used charcoal, a less efficient fuel in terms of its use of wood, but six local women did report buying charcoal when wood was scarce. Table 5 omits data from days on which these other sources of fuel were used.

Table 5 Woodfuel consumption of sample households in Ourosogui, Thiambé, Elévage and Dar-Salaam.

	Number of households in sample	*Consumption (kg person^{-1}day^{-1})*		
		mean	*SD*	*SE of mean*
Type of household:				
Refugees	28	0.90	0.49	0.93
Locals	24	0.85	0.35	0.70
*Stove technology**:				
Three-stone stoves	25	0.80	0.29	0.06
Improved stoves	26	0.96	0.54	0.10
Source of woodfuel:				
Bought	33	0.94	0.49	0.09
Collected	19	0.76	0.26	0.06
Total households sampled	52	0.88	0.43	0.06

* One household had both improved and traditional stoves, and was therefore excluded from analysis.

Data from the woodfuel survey also showed that there was no significant difference ($p > 0.05$) in mean woodfuel consumption between those with 'improved' fuel-efficient stoves, constructed mainly from recycled metal, and those using traditional three-stone stoves (Table 5). In addition, there was no significant difference ($p > 0.05$) between those who bought, and those who collected the majority of their woodfuel.

Discussion

The results presented above suggest that there is little evidence of excessive additional pressures being placed on woodfuel resources in the Senegal River Valley by the refugee population as a result of differences in behaviour between these refugees and the local population. The higher reliance of refugees on collection of woodfuel rather than purchase is likely to reflect lack of availability of cash, and the lower opportunity cost of refugees' time in collection, but nevertheless, both groups rely in part on, and are thus partly regulated in their woodfuel use by the market for woodfuel. The availability of cash is also reflected in the use of alternative fuels, with wealthier local women having access to charcoal, whereas refugee women were more likely to use animal dung.

Overall, refugee women appeared in the survey to be as restrained in their use of woodfuel as local women, although

variation in use patterns within the refugee population was significantly higher. Indeed, if anything, the data presented suggests that it is local women who have the greater environmental impact in their choice of fuel. For example, charcoal production is highly inefficient in its use of wood resources, compared to the negligible impact of the use animal dung on tree cover. The relatively small scale of this use of dung, the fact that it is collected in household corrals, and the fact that much of the livestock producing it were brought to Senegal by the refugees, also mean that there is only a small potential impact on the availability of dung for use as a fertilizer. In general, little or no evidence was found to support the hypothesis that refugees were 'exceptional resource degraders' in this case.

It is also worth noting that the images of 'desertification' and 'deforestation' have themselves been vigorously challenged in recent years, with several authors arguing, for example, that climatic change has a partly cyclical nature, and that vegetation responds directly to this cyclicity. For example, work by Dregne and Tucker (1988) and Tucker *et al*. (1991) using satellite imagery to monitor changes in the 'normalized difference vegetation index' (NDVI) has shown a highly elastic response of vegetation cover (using NDVI as a surrogate) and growing seasonal rainfall, with the 'desert margin' in the Sahel fluctuating from year to year as a result. Specifically, in the middle valley of the Senegal River, Stiles (1990) found that although NDVI was extremely low in the drought years of 1983–84, overall the NDVI increased over the 1980s. Meanwhile, Williams and Balling (1996, p. 50) conclude more generally that evidence that human activities have changed climatic patterns through influencing surface albedo, surface roughness, plant cover and soil moisture remains 'equivocal', whilst management practices that were thought to contribute to land degradation need to be placed in historical context (Mortimore 1989; Thomas & Middleton 1994). In this context, the common view of the Senegal River Valley, and the Sahel in general, as a vulnerable environment undergoing unilineal change, must be treated with caution.

In addition, the figures for woodfuel consumption presented above for the two communities studied are rather low compared with previous studies of woodfuel consumption in the region (cf. von Maydell 1992, p. 28). This may reflect the fact that the survey was carried out during the hot dry season, when fires are extinguished immediately after each meal, and many active household members are absent, such that cooking is mainly for women and children. However, it could also be seen as an indication that scarcity of woodfuel has led to adaptations of behaviour by both refugees and locals which reduce the pressure of demand.

Measures to combat deforestation: fuel-efficient stoves

In addition to examining pressure on woodfuel resources, this study has also considered measures developed to combat this pressure. One major response of those concerned with a 'woodfuel crisis' has been the promotion of new types of cooking stoves that use less fuel, and so reduce demand for wood (Foley *et al*. 1984; Barnes 1993). With potential woodfuel savings of 20–50%, these stoves have also proved of interest to operational assistance agencies in refugee settings (Hoerz 1995*a*; Le Breton 1995). However, the results presented here suggest that such savings may not have been achieved in practice.

In this case study, the stove types used were of a simple local variety, and were generally purchased in a local market or from local blacksmiths. The main reason cited by women for using the stoves was their portability and ease of use, and certainly any potential efficiency gains from using them would be mitigated by other factors, such as failure to match accurately the size of the stove with the size of the pot used. Moreover, the stoves had not been promoted by a development agency in order to reduce woodfuel consumption, or at least no such programme was cited during the interviews. As such, their use was not combined with any education about, or perception of, a need for fuel efficiency. However, it was interesting to note that in the village of Koundel, 'improved' mud stoves had been promoted by a development agency linked to an association of migrants from that village living in France, but that, in this case, virtually all of these mud stoves had fallen into disuse as they cracked or collapsed, and had not been replaced. Indeed, in only one household was a mud stove in use that had been designed specifically to reduce woodfuel consumption; in this case, a male refugee in Elévage had observed the stove in use in an agency compound and had built one himself, although his wife continued to use a three-stone fire alongside the mud stove for certain meals.

A possible explanation for the higher average woodfuel consumption of those using metal stoves might be that those who can afford to buy these stoves are also those who are more able to acquire wood, and therefore use it more freely, a conclusion which could apply independent of the potential fuel-efficiency of the stove *per se*. This notion is supported by data presented in Table 5, which show a higher mean consumption of wood by those who are able to buy it, compared to those who mainly collect wood, although this difference is not significant at the 95% confidence level. These results can also be seen as consistent with the arguments of Dufournaud *et al*. (1994) that as more efficient stoves are introduced, rebound of consumption also occurs as aggregate household income is increased. However, this does not explain the differences observed between consumption of refugee and local women in this instance.

Reforestation

In addition to the promotion of fuel-efficient stoves, a second major component of many environmental rehabilitation programmes in refugee situations involves 'reforestation' activities (Black 1994*a*). Although UNHCR itself developed no specific activities aimed at combating environmental degradation in its Senegal programme, nonetheless various exter-

nal agencies are operating in the middle valley region, and their existence posed at least the possibility of developing an integrated resource management strategy encompassing both refugee and local populations (see Black & Sessay 1995). In the case of some agencies, there is evidence of the incorporation of the refugees into environmental protection activities; however, overall, such external interventions are characterized not only by a failure to integrate refugee populations into mainstream programmes, but also by a general ineffectiveness in tackling the severe environmental problems that exist in the valley.

One example of a semi-integrated programme encountered during this research involved tree-planting activities by the '*Projet Integré de Podor*' (PIP), funded by the European Community. As part of this programme, tree seedlings were distributed in Dodel to both refugee and local households, consisting mainly of 'neem' for planting within compounds. Around 100 trees were reported planted by each of the two groups interviewed, of which roughly 30 of those planted by refugees, and 40 of those planted by locals were still alive at the time of the survey (over a year after their planting). However, tree planting has proved to be only a limited success beyond household compounds, where people look after the seedlings because of their wish for shade. In contrast, two major forestry programmes, Premina (in Podor département) and Progona (covering the whole of the middle valley), appear to have made few attempts to include refugee populations in their activities, being primarily concerned with the planting of trees around modern irrigated perimeters, and the protection of remaining stands of *Acacia nilotica* in the floodplain, respectively. Tree-planting by Premina has produced survival rates (defined as the percentage of trees still alive after five months) of up to 47% amongst 185 individuals collaborating with the programme, although more substantial investments in 141 village groups had by 1991 achieved only a 27% survival rate (Toussaint *et al*. 1994).

On a wider scale, the record of reforestation in Senegal as a whole was reviewed by Sylva (1992), who noted that despite substantial expenditure since the 1970s, there had been little noticeable impact on forest resources, and indeed that the true extent of Senegalese forest resources, and their rate of use, are little known. Sylva (1992) cited a number of reasons for this failure of policy, including the selection of inappropriate tree species, and the fact that trees are often seen by local populations as being a low priority after issues such as agriculture, health and education, particularly given that they tie up capital resources in an economic system where people need 'liquid' assets that are convertible to cash in times of crisis. This conclusion was reinforced by discussions with local and refugee populations as part of this study. Moreover, Sylva (1992) also suggested that confusion and conflict over land rights, in particular between customary and modern law, and between users and the state, as well as a history of repressive forestry codes, have significantly reduced the willingness of populations to participate in tree-planting activities. The presence of the refugees may have contributed to confusion over land tenure (an observation of Toussaint *et al*. 1994, although not confirmed in the villages studied in this research), but any lack of interest of refugees in reforestation must be placed in the context of existing antipathy of local populations.

In general, although refugees and locals were seen to participate to a similar extent in environmental projects that have been implemented in the Senegal River Valley to address deforestation, where they were eligible to do so, these measures were generally found to be marginal in terms of their achievements overall. One explanation for this lack of success concerns the attitudes of locals and refugees to reforestation and stove programmes, which they did not see as addressing their own concerns (Bernard 1993). Shortage of wood for fuel did not appear as a major concern of either the refugee or local households or women interviewed during the research, although rates of woodfuel use were found to be very low, and there was considerable awareness of the burning and other qualities of various tree species that were available. This lack of concern over woodfuel shortages reflects relatively stable prices for wood, and a general perception that tree cover was related to rainfall conditions (and availability of water from annual flooding of the river) rather than to over-use of trees by local populations. This perception itself was reinforced by the observation in 1995 that higher rainfall and the highest flood for many decades had led to significant regrowth of seedlings of *Acacia nilotica* along the river bank.

There is some evidence presented in this paper, notably that on the very low consumption of woodfuel, that shortages of woodfuel do exist in the middle valley of the Senegal River. In turn, these have led to adaptive responses by both local and refugee populations, for example through increased use of the market (which can bring wood from some distance to meet demand), or through switching at certain times of the year to alternative fuels. There may also have been further responses, such as changes in cooking habits (cf. Dewees 1989), although confirmation of this remained largely outside the scope of this research. However, whilst these varied responses may have mitigated undue pressure on local supplies of woodfuel, they do not remove the broader pressure on livelihoods, or indeed on human health, that may have resulted from physical scarcity of wood. If such problems are to be addressed, the lesson of this research is that policy interventions need to be targeted at both refugee and host populations if they are to be successful.

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