

Moving Up or Moving Out? Insights into Rural Development and Poverty Reduction in Senegal

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Summary. — While worldwide progress in poverty reduction has been impressive, Sub-Saharan Africa is lagging behind with slow growth and a high-poverty headcount ratio. There are fierce debates on how Sub-Saharan Africa can foster pro-poor growth and the role of agriculture and small- versus large-scale farming in poverty reduction. We contribute to this debate with micro-economic empirical evidence from the Senegal River Delta, an area that recently experienced rapid rural development. We use household survey data from two panel rounds in 2006 and 2013 and a cluster analysis to investigate livelihood, income, and poverty dynamics in the region. We find that with 4.3% annual growth in average household income, 29.5 percentage points' poverty reduction, and 4.2 percentage points' inequality reduction over the period 2006–13, development in the Senegal River Delta region has been remarkably pro-poor. Income growth and poverty reduction have been most impressive among households moving into wage employment on large-scale horticultural export farms and in an emerging service sector. Income growth in small-scale agriculture and non-farm businesses has been more modest but has affected the largest number of households. Transformation in both farm and non-farm sectors has driven rural development in the Senegal River Delta region, and investments in both large- and small-scale agriculture have contributed importantly to household income growth and poverty reduction. Our findings imply that (foreign) investments in large-scale commercial and export-oriented farming can trigger pro-poor growth—directly through employment effects and indirectly through investment and consumption linkages with the small-scale farm and non-farm sector.

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1. INTRODUCTION

The first Millennium Development Goal to halve by 2015 the proportion of people who are poor has been met. Worldwide progress in poverty reduction has been impressive: the global poverty headcount ratio decreased from 37.1% in 1990 to 12.7% in 2012¹ (World Bank, 2015). Yet, progress in poverty reduction is lagging behind in Sub-Saharan Africa (SSA), especially in rural areas. The SSA poverty headcount ratio remains high at 42.7% in 2012 and has decreased only with 14.1 percentage points from the 1990 ratio (World Bank, 2015). Strategies to further reduce poverty and stimulate, especially rural, development are still highly needed. The target of eradicating extreme poverty completely by 2030 in the new Sustainable Development Goals, will require substantial attention to development in rural areas in SSA as this is where the incidence and depth of poverty remain most problematic.

Economic development paradigms and the role of agriculture in economic development and poverty reduction have been debated intensively. Throughout the past half a century the overall development paradigm has shifted from a narrow focus on structural transformation through rapid industrialization in the 1960s and 1970s; to a focus on agricultural transformation as an important component of structural transformation and pro-poor economic growth in the 1980s and 1990s; and to contemporaneously opposing schools of thought (Diao, Hazell, & Thurlow, 2010). The recent debate includes advocacy of agricultural transformation as an essential component of economic development and poverty reduction (e.g., Byerlee, de Janvry, & Sadoulet, 2009; Christiaensen, Demery, & Kuhl, 2011; World Bank, 2007) as well as scepticism, and even pessimism, about the role agriculture has to play in fostering pro-poor growth (e.g., Dercon & Gollin, 2014; Ellis, 2005; Maxwell & Slater, 2003). In recent years, the debate has become more complex and turned to the importance of small-scale versus large-scale agriculture in economic development (e.g., Collier & Dercon, 2014; Larson, Muraoka, & Otsuka, 2016; Wiggins, Kirsten, & Llambí, 2010) and food versus export sector development (e.g., Diao & Dorosh, 2007; Diao & Hazell, 2004; Rosegrant, Paisner, Meijer, & Witcover, 2001). These debates are especially fierce when it concerns Sub-Saharan Africa (SSA), where growth and poverty reduction are lagging behind.

In this paper, we provide micro-economic empirical evidence in this debate. We investigate livelihood and poverty dynamics in the Senegal River Delta area in Senegal over a period of seven years. During that period, the region has experienced substantial poverty reduction—much faster than in other parts of Senegal or SSA in general—and rapid rural development, which makes it a particularly relevant case to assess the factors contributing to rural development. We use household survey data from two panel rounds in 2006 and 2013 to estimate livelihood, income, and poverty dynamics in the region. We apply a cluster analysis to classify households in livelihood strategy groups, to reveal which groups

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improved their well-being most and which income sources were most important in household income growth. We discuss our findings in light of the debates on structural and agricultural transformation, and on small- and large-scale farming. Our results point to complementarities between structural and agricultural transformation and between small- and large-scale farming. While most evidence in these debates comes from macro-economic and cross-country studies, we provide complementary micro-economic evidence and indepth insights from an area that has been particularly successful in increasing rural incomes and reducing poverty. In-depth knowledge from such a success-story can provide substantiation in the debate on rural development. We take into account the dynamics and complexity of rural development using panel data and a livelihood approach. Our approach is complementary to more quantitative impact evaluation that often focuses on a single causal impact and fails to capture complexity and heterogeneity across rural households; and to existing livelihood studies that most often use cross-sectional data and fail to capture dynamics over time.

2. LITERATURE REVIEW

The role of agriculture in economic development and poverty reduction has been debated intensively during the past half a century. Inspired by Lewis' (1954) idea of dual economic structures, development economists in the 1960s and early 1970s believed in structural transformation-an increase in per capita income associated with a declining share of agriculture in GDP and employment—and economic development through rapid industrialization. Agriculture was considered a backward sector not contributing to overall economic growth and only of importance to guarantee food supply and keep food prices from rising. Underpinned by the observations of Schultz (1964) and Ruttan and Hayami (1971) that farmers are efficient and adopt technological innovations, the paradigm changed to agricultural transformation-the transformation of a low-input low-return agricultural sector to a modern science-based and high-return agricultural sector-being an essential component of (early) structural transformation and economic development. Through new agricultural technologies and agricultural intensification, agricultural development was thought to contribute to overall economic growth-directly through increasing productivity within agriculture, and indirectly through linkages with the non-farm sector and growth multiplier effects (Delgado, Hopkins, & Kelly, 1998; Haggblade, Hazell, & Brown, 1998; Haggblade, Hazell, & Reardon, 2010; Irz, Lin, Thirtle, & Wiggins, 2001). The agricultural transformation paradigm has been substantiated by the Green Revolution in the 1970s in Asia, where technological innovations and agricultural intensification resulted in agricultural growth and through growth multiplier effects-especially through backward and forward production linkages with the agro-input and food-processing industryalso in overall economic growth.

More recently, agricultural transformation has been argued to be important not only because of growth multiplier effects and the contribution to overall economic growth but particularly because it fosters pro-poor economic growth and reduces inequality (Byerlee *et al.*, 2009; Ravallion & Chen, 2003). Christiaensen *et al.* (2011) and Diao *et al.* (2010) provide cross-country econometric and case-study evidence that in SSA agricultural growth is more effective in reducing poverty than non-agricultural growth. However, proponents of agriculture-led growth strategies do argue that in addition to technological innovations and intensification, agricultural transformation also requires supply chain innovations in order to create better access to markets, more efficient exchange, and increased value-adding (Byerlee *et al.*, 2009).

Yet, scepticism and pessimism about agriculture-led growth in SSA is arising as well (Dercon & Gollin, 2014; Ellis, 2005; Maxwell & Slater, 2003). Sceptics recognize the importance of agricultural transformation for poverty reduction but argue that after decades of stagnating yields and poor performance, the agricultural sector in SSA failed to be a major driver of overall economic growth. Dercon (2009) points out that because of increased globalization and downward pressure on food prices, intersectoral linkages and the potential for growth multiplier effects are less strong in SSA today than they were in Asia at the time of the Green Revolution. Opponents of agriculture-led growth strategies focus on diversifying rural incomes away from agriculture and migration to urban areas (Collier & Dercon, 2014). Using data from five African countries, Dorosh and Thurlow (2016) find that poverty elasticities of non-agricultural sector growth, including services and manufacturing (also agro-processing), are often close to elasticities of agricultural sector growth-and sometimes exceed them.

On the other hand, Diao *et al.* (2010) argue that many rural households in SSA have diversified their incomes into off- and non-farm activities for decades, without resulting in rapid income growth. The return to off- and non-farm activities is often observed to be smaller than the return to farm activities (Andersson Djurfeldt & Djurfeldt, 2013), and diversification is said to serve income smoothing rather than income growth (Barrett, Reardon, & Webb, 2001; Davis *et al.*, 2010; Haggblade *et al.*, 2010; Rigg, 2006).

In recent years, the debate has become more complex and turned to the role of smallholder farming versus large-scale farming in fostering agricultural and structural transformation and economic development. Some authors argue that propoor growth in SSA should emerge from productivity increases in smallholder agriculture (Larson et al., 2016; Mellor & Malik, 2017; Wiggins et al., 2010). The advocacy of smallholder farming is based on the hypothesis of an inverse farm size-productivity relation and the resulting higher allocative efficiency on smallholder farms; and on the experience with the Green Revolution in Asia which has been largely smallholder based. Increasing smallholder farm incomes may directly result in poverty reduction and additionally create multiplier effects through consumption linkages because smallholders are more likely to be poor and to spend additional income on locally produced non-agricultural goods and services, thereby stimulating the rural nonfarm economy.

Others are more sceptical and question the exclusive focus on smallholder agriculture as development paradigm in SSA (Collier & Dercon, 2014; van Vliet et al., 2015). An argument in favor of large-scale farming is that while smallholders may allocate resources more efficiently and operate at a higher allocative efficiency, large-scale farms are more likely to operate closer to the technical frontier at a higher technical efficiency (Collier & Dercon, 2014). There is a parallel debate on whether agricultural transformation is associated with export sectors or domestic food sectors (Diao et al., 2010). While some argue that the development of export sectors, especially non-traditional export sectors, creates opportunities for pro-poor growth (Aksoy & Beghin, 2004; Swinnen, 2007), others have argued that the contribution of such export sectors to overall growth is limited and that the largest potential lies in the development of food sectors for domestic and regional markets (Diao & Dorosh, 2007).

3. DATA

(a) Research area

Our research area is the area around the Senegal River Delta, located in the region of Saint-Louis in the northern Sahel part of Senegal, upstream of Saint-Louis town and the estuary of the Senegal River (Figure 1). It is bounded by the Senegal River and the border with Mauretania in the northwest and the N2, the national road that connects the towns of Saint-Louis, Ross-Béthio, and Richard-Toll, in the east. The area stretches over two rural communities, Gandon and Diama, in two of the three departments in the region, Saint-Louis and Dagana.

The research area is situated at the mouth of the Senegal River Valley, which is the main irrigated rice area in Senegal. The Senegal River Valley accounts for 44% of the total national rice acreage and almost 70% of national rice production (Tanaka, Diagne, & Saito, 2015). With a dry season from November to July, rice producers need to irrigate using water from the Senegal River and its tributaries. In order to increase rice production and become less dependent on imports, the Senegalese government has heavily invested in developing new irrigation perimeters or restoring neglected irrigation schemes. The entire irrigated rice area increased from 51,000 ha in 2008 to 103,000 hectares in 2011 (Sakurai, 2016).

Recently the region has become one of the two principal horticultural export areas in Senegal, besides the Niayes region north of Dakar. Since the mid 2000s five horticultural export companies established in the region, mostly through foreign direct investment. The cultivated area is still expanding as established companies seek to expand their activities. Product variety has increased but tomatoes, beans, and mangoes are the main export crops, largely destined for the European market. Production mainly occurs from October to May, when horticultural production in Europe is less competitive. The companies all use a vertical integration strategy and lease land from rural communities to establish large-scale estate farms and one or several conditioning units.

Households in the research area belong to Wolof, Peulh, and Maure ethnic groups. The majority of them are Muslim and live in large extended families within one compound. Traditionally, households in the research area are farmhouseholds deriving the majority of their income and livelihood from cropping and livestock-rearing. Cropping is traditionally most common for Wolof households while Maure people are typically goat-keepers and Peulh cattle herders; the latter used to be (semi-)nomadic but started to become sedentary from the 1970s onward. This traditional ethnic livelihood distinction is becoming faint and farm activities are becoming more mixed. Cropping systems currently include irrigated rice production and vegetable production with onions, tomatoes, and beans as most common crops. Commercial livestock activities include selling of meat and milk from cattle, goats, and sheep. Households complement their farm income with wages earned in the horticultural export companies. Small business activities, such as petty trade, hairdressing, and tailoring are also common in the area.

(b) Data collection

We conducted fieldwork in this area in the period 2006–13 and collected data from several sources. First, we conducted semi-structured interviews with the major investors and research institutes in the area, and compiled existing reports and secondary statistics. We interviewed all five horticultural export companies—the oldest ones several times throughout the period—on production activities, sourcing strategies, employment strategies, and working conditions. We interviewed international and government agricultural research institutes and extension agencies to get information on investments in rice and livestock production in the area: AfricaRice, ISRA (*Institut Sénégalais de Recherches Agricoles*), and SAED (*Société d'Aménagement et d'Exploitation des terres du Delta*



Fig. 1. Map of research area: sampled villages in the rural communities of Gandon and Diama. Source: ESRI (Environmental Systems Research Institue).

du Fleuve Sénégal). We also interviewed APIX (*Agence de Promotion des Investissementset Grand Travaux*), the national investment promotion agency.

Second, we conducted a two-round household survey in the area, with the first baseline round implemented in February-April 2006 and the second follow-up round in April—June 2013. The first survey round covered 284 households in 17 villages across the two rural communities Gandon and Diama. We used a two-stage stratified sampling design. In the first stage, villages were stratified according to their distance to the road and randomly selected within the strata with an oversampling of villages closer to the road. This resulted in three clusters of sampled villages: 1/villages located along the N2 north-east of Gandon in the community of Diama, 2/villages located along the smaller road to the Senegal River dam and the border with Mauretania, and 3/villages in the community of Gandon (Figure 1). In the second stage, households in the sampled villages were stratified according to whether or not members of the household are employed in the horticultural export industry and randomly selected within the strata with an oversampling of households with employment. In the second survey round, there was an attrition rate of 8.8% because 25 sampled households moved out of the region. This attrition is deemed to be sufficiently low because relocated households are not statistically different from other sampled households. Four observations are not retained for analysis in this paper because of missing information. The final sample consists of a balanced panel data set of 255 households. To draw population inferences from descriptive statistics and correct for oversampling of households close to the road and employed in the horticultural export sector, we use sampling weights that are calculated with census information from the rural communities and villages. A structured quantitative questionnaire was used² and survey data include information on demographic characteristics, productive assets, living standards, and income sources from agricultural production (both crop and livestock production), off-farm wage employment and self-employment, and non-labor income (mainly remittances). Income data are collected for the 12-month period prior to the survey. We complemented the household survey with a village survey to collect information on geographical and institutional characteristics of the sampled villages.

4. METHODS

(a) Income, poverty, and inequality calculations

We calculate income per adult equivalent for both survey rounds. We define total income as the income a household earned during the 12 months before the survey. We include different sources of income: crop production, livestock rearing, off-farm wage employment, off-farm self-employment, and non-labor income, such as received remittances and state subsidies. We use real income data to compare income over time and inflate all income data to 2013 price levels using consumer price indices (IMF, 2015). We use the modified OECD adultequivalence scale with a value of 1 for the household head, 0.5 for each additional adult member and 0.3 for each child. We define a household as all members who lived, slept, and ate together in the same compound for at least six months during the past year.

We derive incidence of poverty and extreme poverty using the national rural poverty and extreme poverty line of 2011, which we adapt to 2013 price levels using consumer price indices (République du Sénégal, 2014). A household is poor if per adult equivalent income is lower than 225,909 FCFA per year and extremely poor if it is lower than 141,521 FCFA per year³. Because poverty measures based on income have been criticized for not distinguishing chronic from transitory poverty (Carter & Barrett, 2006), we also calculate poverty based on the Multidimensional Poverty Index (MDPI) which takes into account households' living standards, assets, health, and education and is a measure for more structural poverty (Alkire & Santos, 2010). We have MDPI data only for 2013. We calculate income inequality using the Gini coefficient. We correct all population statistics using sampling weights.

(b) Analysis of livelihood strategies

A livelihood strategy (LS) is defined as a combination of activities a household chooses to undertake in order to reach their desired welfare level (Ellis, 2000). It is influenced by households' access to capital and productive assets, which is governed by policies and institutions. It captures households' dynamic aspirations and the diversity among them, and allows to assess the wider sectoral, intersectoral, and macroeconomic policies that are necessary to realize those aspirations (Dorward *et al.*, 2009).

We classify sampled households in LS categories using a cluster analysis, which divides a large number of multivariate observations into smaller subgroups by maximizing intragroup homogeneity and inter-group heterogeneity. We use survey data on households' labor allocation to classify households according to the income-generating activities they pursue in the period 2006-13. Other livelihood studies have classified households based on income sources (e.g., Babulo et al., 2008; Liao, Barrett, & Kassam, 2015; Rahman & Akter, 2014) or on human capital and location (e.g., Ansoms & McKay, 2010; Petrovici & Gorton, 2005). We follow the rationale that labor allocation reflects households' LS. and that income is an outcome of these strategies while access to productive assets and location are factors determining households' strategies (Jansen, Pender, Damon, Wielemaker, & Schipper, 2006; van den Berg, 2010).

Concretely, we distinguish four main income-generating activities: crop production, livestock rearing, off-farm wage employment, and off-farm self-employment. We use eight variables for both years in the cluster analysis. The first four variables describe households' labor allocation to the four activities and are defined as the share of the available family labor spent on each of the four main activities (i.e., the number of actual workers in an activity over the total number of workers in the household). The other four variables describe the time allocation of individual household members and are defined as the share of labor time spent by household members on each of the four main activities (i.e., the actual time spent by workers in an activity over workers' total labor time). We use proportional values rather than absolute values as these better reflect the chosen LS and are not sensitive to outliers in household sizes. To chronologically link the LS between the two survey years and to model the transformation over time, we calculate the eight labor allocation variables for both 2006 and 2013. Thus, a household's LS is represented by 16 variables in total, which are used in a cluster analysis to quantitatively classify households in LS classes.

We apply a factor analysis to reduce the correlation between the 16 labor allocation variables. We retain four factors with an eigenvalue higher than one, and perform a varimax rotation to ease the interpretation of the factor loadings. We use the predicted factor scores as input for the cluster analysis. We use a hierarchical clustering method using Ward's linkage and squared Euclidean distance as similarity measure. We additionally apply a k-means cluster analysis to correct for possible misclassification of observations at the boundaries between clusters, using the number of clusters and the means of each variable of the Ward's linkage clustering as starting values for the k-means analysis. We determine the number of clusters based on the dendrogram and find that heterogeneity is maximized across clusters and minimized within clusters if four clusters are retained. Hence, the analysis results in four LS classes.

(c) Determinants and outcomes of livelihood strategies

To reveal which household characteristics determine LS, we run a multinomial logit model with the LS classification as categorical dependent variable. Covariates in the model include indicators of human capital (age, gender, and schooling of the household head, total number of household members. and dependency ratio), physical capital (land and livestock assets), social capital (ethnicity), and location (sub-region dummies). To avoid reverse causality, we use baseline (2006) covariate values only. We additionally include a variable that controls for a change in household head between 2006 and 2013, as the decease of a household head might cause an abrupt change in households' LS. We calculate and report average marginal effects, which are interpreted as the effect of a one-unit change in an explanatory variable on the probability of a household choosing a particular LS. In addition, we present income and poverty statistics for the different LS classes.

5. RESULTS

(a) Income and poverty dynamics

Our results show that development in the Senegal River Delta has been remarkably pro-poor. During 2006 and 2013, average total household income increased with 34.1%. This comes down to an annual income growth rate of 4.3%, which is higher than annual GDP growth in Senegal (3.5% in 2013) but slightly lower than growth in SSA in general (4.6%) in 2013) (World Bank, 2015). Yet, the rate at which poverty reduced in the Senegal River Delta is spectacular. The share of poor households decreased from 56.2% to 26.7%-a reduction of 29.5 percentage points (pp)-and the share of extremely poor households from 30.8% to 17.4%—a reduction of 13.4 pp (Figure 2)⁴. Poverty reduction has been much sharper than in Senegal in general-where poverty and extreme poverty increased slightly from 65.8% and 37.6% in 2005 to 66.3% and 37.6% respectively in 2011-and in SSA with 5.2 pp reduction in poverty and 6.1 pp reduction in extreme poverty over the period 2005–11 (World Bank, 2015)⁵. In addition, the Gini coefficient for the Senegal River Delta decreased with 4.2 pp from 42.8% in 2006 to 38.6% in 2013; which is again in contrast with a slight increase in the Gini coefficient from 39.2% in 2005 to 40.3% in 2011 for Senegal in general. These figures show that income growth in the Senegal River Delta has been particularly pro-poor; both according to the weaker absolute definition of pro-poor growth, as it resulted in a reduced poverty headcount ratio, and according to the stronger relative definition of pro-poor growth, as it contributed to reducing inequality (Kakwani & Pernia, 2000).



Fig. 2. Headcount ratio of people living below poverty and extreme poverty lines. Source: National data are derived from World Development Indicators (World Bank, 2015) and Senegal River Delta data are calculated based on own survey data using sampling weights. Poverty measures of SSA and Senegal are based on international poverty lines, and poverty measures of Rural Senegal and Senegal River Delta are based on national rural poverty lines (République du Sénégal, 2014).

In addition to a sharp reduction in income poverty and inequality, living standards improved in the Senegal River Delta. Households' access to electricity increased with 30 pp (from 45% in 2006 to 75% in 2013); access to clean drinking water increased with 46 pp (from 48% to 94%); telephone ownership increased with 51 pp (from 48% to 99%); and distance to an all-weather road decreased from 3.65 km to 1.59 km. This is an indication that also non-monetary dimensions of poverty improved. Looking at the MDPI as a nonmonetary measure of poverty, we find that in 2013 43.4% of households are multidimensionally poor and that the MDPI is strongly and significantly (at the 1% level) correlated with per adult-equivalent income with a correlation coefficient of -0.31. This complements our findings from income-based measures of poverty.

(b) Livelihood strategies

(i) Labor allocation

The cluster analysis on the labor allocation of households in 2006 and 2013 (see Table 6 in appendix for details on the outcome) results in four different livelihood strategies: 1/crop production and self-employment (LS-crop); 2/livestock rearing and self-employment (LS-livestock); 3/transition to wage employment (LS-transition); and 4/wage employment (LS-wage). LS-crop is the largest category representing 49% of households in the region; followed by LS-transition representing 29%, LS-wage 16% and LS-livestock 6% (Table 1).

Figure 3 presents the labor allocation in the LS classes. Households in LS-crop use on average about 40% of their labor in crop production and another 40% in non-farm businesses. Family labor in wage employment decreased from about 30% in 2006 to 10% in 2013; resulting in more labor allocated to crop production and non-farm businesses. Households in LS-livestock allocate about 50% of family labor to livestock rearing and about 35% to off-farm businesses, with fairly stable labor allocated to crop production or wage employment. Households in LS-transition shifted family labor from non-farm businesses to off-farm wage employment, resulting in an average of 80% of labor being allocated to wage employ-

WORLD DEVELOPMENT

Table 1. Location of livelihood strategies									
Livelihood strategy (LS)	Population share in the Senegal River Delta	Sample share in the LS classes							
		Gandon	Road to Diama	Road to Ross-Béthio					
LS-crop: Crop production and self-employment	48.95%	21.24%	17.96%	60.80%					
LS-livestock: Livestock and self-employment	6.35%	5.84%	69.01%	25.14%					
LS-transition: Transition to wage employment	29.13%	75.09%	14.75%	10.16%					
LS-wage: Wage employment	15.57%	88.51%	4.07%	7.42%					

Sampling weights are taken into account. "Gandon" represents a cluster of villages along the N2 road close to Saint-Louis town and the horticultural export company that was established in 2003. "Road to Diama" represents a cluster of villages along the road to Diama dam where two horticultural companies started exporting in 2007. "Road to Ross-Béthio" represents a cluster of villages along the N2 road further away from Saint-Louis town.



Fig. 3. Shares of average labor allocation of four different livelihood strategies (LS). LS-crop: Crop production & self-employment, LS-livestock: Livestock & self-employment, LS-transition: Transition to wage employment and LS-wage: Wage employment.

ment in 2013. Households in LS-wage spend most of the family labor on wage employment both in 2006 and 2013 but increased labor allocated to non-farm businesses. While 38% of these households had their own non-farm business in 2006, this increased to 80% in 2013.

(ii) Determinants

Table 2 reports the results from the multinomial logit model on the determinants of households' LS and Table 7 in appendix describes the socio-economic characteristics of the four LS classes. LS are importantly determined by location and ethnicity. Households in LS-crop are primarily ethnic Wolof households and live further away from Saint-Louis town, mainly along the road to Ross-Béthio and close to a tributary of the Senegal River as they need water to irrigate rice fields. LS-livestock is common among Maure households who mainly live along the road to Diama, which is close to the border with Mauretania where most of these households are originally from. Households in LS-transition and LS-wage live closer to Saint-Louis town and the first horticultural export company that was established in 2003. LS-transition is more common among Wolof households and LS-wage among Peulh households. The importance of location is confirmed by the figures in Table 1 showing the geographical distribution of the LS classes across three sub-regions (Gandon, Road to Diama, and Road to Ross-Béthio). In addition, results in Table 2 show that LS-crop is more likely among smaller households with larger landholdings and more livestock, LSlivestock and LS-wage among households with more livestock and LS-transition among households with less land and livestock but more family labor. Characteristics of the household head (e.g., age, gender, education) do not seem to influence the choice of livelihood strategy; neither does the change of a household head.

(iii) Outcomes

Figure 4 presents for each LS how income and poverty levels changed over time. We observe three main trends in these income and poverty dynamics. First, households of LStransition experienced the highest income growth and poverty reduction. While households of this category were among the poorest in 2006, their poverty headcount ratio reduced to 25.5% in 2013. Their total household income increased with 67.6% and income per adult equivalent with 102.6%. Second, other households were also able to boost income and reduce poverty, although not to the same extent. The incidence of poverty among households of LS-crop decreased with 14.9 pp and income per adult equivalent increased with 53.0%, but the incidence of extreme poverty or total household income did not change over time. Similarly, the incidence of poverty among households of LS-livestock decreased with 17.9 pp and income per adult equivalent increased with 96.2%, but neither incidence of extreme poverty nor total household income changed over time. Third, households of LS-wage have overall the highest income levels and lowest poverty levels. The difference in welfare with households in other LS is more pronounced in 2006 than in 2013, as the income increase over time of other strategies was relatively larger.

(c) Explaining income growth and poverty reduction

Based on results about income sources across the different LS (Figure 5) and information from the semi-structured inter-

	LS-crop: Crop production and self-employment	LS-livestock: Livestock and self-employment	LS-transition: Transition to wage employment	LS-wage: Wage employment
HH head change (dummy)	-0.112	0.027	0.058	0.027
	(0.092)	(0.064)	(0.073)	(0.072)
Age of HH head (years)	0.002	-0.001	0.000	-0.001
	(0.002)	(0.002)	(0.002)	(0.002)
Female HH head (dummy)	0.024	0.087	-0.040	-0.071
	(0.143)	(0.090)	(0.122)	(0.120)
HH head education (dummy)	-0.048	0.005	0.002	0.041
	(0.073)	(0.050)	(0.062)	(0.055)
HH size (number)	-0.009^{***}	-0.002	0.009^{***}	0.002
	(0.003)	(0.002)	(0.003)	(0.002)
Dependency ratio (%)	-0.037	0.053	-0.015	0.000
	(0.183)	(0.113)	(0.163)	(0.150)
Total land (ha)	0.020^{*}	0.001	-0.033^{*}	0.012
	(0.012)	(0.007)	(0.018)	(0.010)
Total livestock units (TLU)	0.016^{**}	0.007^{***}	-0.032^{**}	0.009^{*}
	(0.007)	(0.002)	(0.013)	(0.005)
Wolof ethnicity (base level)				
Peulh ethnicity	-0.217^{***}	0.060	0.031	0.125**
	(0.075)	(0.064)	(0.061)	(0.049)
Maure ethnicity	-0.157^{*}	0.101***	-0.033	0.089
	(0.089)	(0.049)	(0.085)	(0.098)
Location: Gandon (base level)				
Location: Road to Diama	0.161^{*}	0.191**	0.063	-0.415^{***}
	(0.095)	(0.076)	(0.095)	(0.087)
Location: Road to Ross-Béthio	0.491***	0.026	-0.134^{**}	-0.383^{***}
	(0.071)	(0.036)	(0.063)	(0.073)

Table 2. Average marginal effects, estimated from a multinomial logit model with livelihood strategy as dependent variable

Covariate values are for 2006 and are described in Table 7 in Appendix. Standard errors are reported between parentheses. HH means household. Significant effects are indicated with p < 0.1, p < 0.05, or p < 0.01.

views with key stakeholders in the region, we describe the main factors behind the income and poverty dynamics in the Senegal River Delta.

(i) Crop production

Crop production remains an important source of households' income in the Senegal River Delta, especially for households of LS-crop, which includes about half of the population (Figure 5). Their increase in income is mainly driven by an increase in income from crop production; from 374,000 FCFA in 2006 (28.1% of total income) to 613,000 FCFA in 2013 (40.2% of total income). Table 3 presents some statistics related to crop production for the whole area and for sampled households of LS-crop. Rice is the main cultivated crop, grown by 36% of households in the area, but farmers increasingly produce other crops as well, such as tomatoes, beans, and onions. Increases in crop income mainly follow from rice area expansion and rice price increases, and not from yield increases. The average rice yield decreased over time, from 4.72 ton/ha in 2006 to 3.26 in 2013. These yields are comparable to the average of 3.62 ton/ha in irrigated rice cultivation in SSA (Rodenburg & Johnson, 2009), but far below potential vields that can mount up to 9-12 ton/ha (Diagne, Demont, Seck, & Diaw, 2013). The use of inputs, such as fertilizer and pesticides, did not change over time, as nearly all farmers already applied these inputs in 2006. Our data are not detailed enough to estimate changes in the quantity of fertilizer or pesticides applied.

On the other hand, farmers of LS-crop were able to expand their landholdings; the average area cultivated with rice increased from 1.56 ha to 3.40 ha. All rice plots are irrigated and nearly all plots are owned by the household who cultivates the plot; only very few plots (3% in 2013) are rented. Our findings document the government policy of stimulating rice area expansion by developing new irrigation perimeters. This policy was heavily criticized: studies by de Mey, Demont, and Diagne (2012), Demont and Rizzotto (2012) and Diagne *et al.* (2013) stress the need to increase rice productivity by tackling the various institutional and biological constraints that smallholder rice farmers in the Senegal River Delta face. As a response to these concerns, the government modified the program in 2012 toward subsidizing fertilizer, providing agricultural equipment, and attracting private investors in addition to area expansion (République du Sénégal, 2012). The effects of these investments are not yet visible in our data.

In addition, the farm-gate price of rice increased substantially over the seven-year period; it more than doubled from 126 FCFA/kg in 2006 to 281 FCFA/kg in 2013. This price increase is not driven by supply chain upgrading, quality upgrading, or higher local demand, but is associated with fluctuations in international market prices and the price shocks of 2008–09. The international rice price was on average about \$300 per ton in the 2005–06 season and about \$570 per ton in the 2012–13 season, which corresponds to 150 and 285 FCFA/kg respectively (World Bank, 2015). With a sharp price increase and a substantially expanded rice area, farmers are selling an increased proportion of total rice production (14% in 2006 and 40% in 2013).

(ii) Livestock rearing

Although livestock is kept by more than half of the households in the Senegal River Delta, it plays a small role as income-generating activity, except for households of LSlivestock (Figure 5). They derive a substantial share of total income from livestock (34.2% in 2006 and 23.8% in 2013) but average revenues from livestock production declined over



Fig. 4. Income and poverty levels of four livelihood strategies (LS) in 2006 and 2013. (A) Total household income (1,000 FCFA/year), (B) Income per adult equivalent (1,000 FCFA/year), (C) Share of households who live below national rural poverty line and (D) Share of households who live below national rural extreme poverty line. LS-crop: Crop production & self-employment, LS-livestock: Livestock and self-employment, LS-transition: Transition to wage employment and LS-wage: Wage employment. Error bars represent the standard error of the means.



Fig. 5. Income sources of four livelihood strategies (LS) in 2006 and 2013. LS-crop: Crop production & self-employment, LS-livestock: Livestock and selfemployment, LS-transition: Transition to wage employment and LS-wage: Wage employment. Error bars represent the standard error of the means.

time (from 508,000 FCFA to 443,000 FCFA). Nevertheless, households of LS-livestock were able to expand their herds of cattle and small ruminants (i.e., goats and sheep). Compared to other households, they also apply more inputs; 73% gave industrial feed to their cattle in 2013 (especially in the dry season), while this is only 34% for all other cattle holders

in the sample. Apart from being an income-generating activity, livestock is used as savings mechanism and meat and milk products are used for subsistence purposes. Our findings imply that the program PNDE (*Plan National de Développement de l'Elevage*), which the Senegalese government launched in 2011 to improve the dairy and meat value chain, did not

Table 3. Characteristics of crop production								
	Senegal 1	River Delta ¹	LS: Crop production and self employment					
	2006	2013	2006	2013				
Share of households involved in								
Crop production (%)	48.64	44.58	75.21	71.90				
Rice production (%)	39.35	35.85	70.25	57.85**				
Horticultural production (%)	3.70	11.30	13.22	8.26				
Number of crops ²	1.54	1.87	1.42	1.63				
•	(0.15)	(0.15)	(0.08)	(0.10)				
Rice yield (kg/ha)	4,720	3,261	3,668	2,804***				
	(771)	(510)	(206)	(265)				
Rice $area^2$ (ha)	1.46	1.08	1.56	3.4*				
	(0.24)	(0.16)	(0.18)	(1.32)				
Rice selling price (FCFA/kg)	126.59	281.05****	124.5	261.93****				
	(8.83)	(32.18)	(4.86)	(21.33)				
Share of rice sold (%)	13.93	39.47***	27.44	43.28***				
. /	(2.69)	(6.71)	(2.94)	(0.04)				

Significant differences are indicated with $p^* < 0.1$, $p^* < 0.05$, or $p^* < 0.01$. Standard errors are reported between parentheses for continuous variables. ¹Population statistics are derived using sampling weights.

²Conditional on having crop production.

(yet) succeed in the Senegal River Delta. Investments include establishment of dairy product collection centers, introduction of high-potential dairy breeds, and subsidizing industrial feed. In addition, the NGO AVSF (*Agronomes et Vétérinaires Sans Frontières*) invested in improved veterinary services and better access for smallholder farmers to these services (see Table 4).

(iii) Development of a horticultural export sector

Employment in horticultural export companies and the development of a horticultural export supply chain have been major drivers of poverty reduction in the research region. Horticultural exports from Senegal increased tremendously over the past years—from 5.8 million US\$ in 2003 to 57.7 million US\$ in 2014 (Comtrade, 2015). The sharp boom in horticultural exports fits within Senegal's strategy of agricultural export diversification toward higher value commodities, which was adopted since the devaluation of the FCFA in 1994 and after decades of dependency on groundnuts as the main agricultural export commodity throughout the 1960s, 1970s, and 1980s. The development of the horticultural export companies,

mainly foreign direct investment, and public investments. The government has played an active role in attracting foreign investors in the sector—through the investment promotion agency APIX that was established in 2000; in establishing cold storage facilities at the airport and the main harbor in Dakar, laboratory testing of food quality and safety aspects; and the establishment of the label *Origine Sénégal* in 2010 as a tool to promote fruit and vegetable exports from Senegal. The sector also received some donor support, e.g., assistance from the ColeACP-PIP program financed by the EU.

Based on interviews with the companies, we estimate that approximately 5,000 people in the Senegal River Delta are employed on the fields and in the conditioning units of the companies in 2013. Especially households of LS-transition (73%) and LS-wage (93%) are employed in the export companies and their wages contribute importantly to their high income level. The spectacular increase in income of households of LS-transition is mainly driven by an increase in income from wage employment; it almost quadrupled from 472,000 FCFA in 2006 (34% of total income) to 1,646,000 FCFA in 2013 (71% of total income) (Figure 5). For these

Table 4.	Characteristics	of livestock	rearing

	Senegal R	iver Delta ¹	LS: Livestock and self-employ	
	2006	2013	2006	2013
Share of households who				
Own livestock (%)	59.95	49.68	92.86	100.00
Own cattle (%)	25.79	13.20*	64.29	78.57
Own small ruminants ² (%)	52.65	38.04*	85.71	89.29
Total herd size ³ (TLU)	8.58	5.43	16.75	20.62
	(1.81)	(1.12)	(5.05)	(3.86)
Number of cattle ³	6.04	3.60	13.08	15.50
	(1.51)	(0.99)	(4.35)	(3.08)
Number of small ruminants ³	9.59	7.05	11.62	24.54*
	(0.02)	(0.01)	(2.39)	(5.97)

Significant differences are indicated with $p^* < 0.1$, $p^* < 0.05$, or $p^{***} < 0.01$. Standard errors are reported between parentheses for continuous variables. Population statistics are derived using sampling weights.

² Small ruminants are goats and sheep.

³Conditional on livestock ownership.

households, wages earned in the export companies contribute on average 85% to income from wage employment in 2006 and 46% in 2013. For households of LS-wage, income from wage employment remained quite stable over time; from 2,059,000 FCFA in 2006 (69% of total income) to 2,004,000 FCFA in 2013 (62% of total income). A major share of this income is derived from wages earned in the export companies: 89% in 2006 and 78% in 2013. Maertens, Colen, and Swinnen (2011) and Van den Broeck, Swinnen, and Maertens (2017) previously showed that employment in the export sector increases household income, particularly for poorer households.

Table 5 describes some characteristics of employment in the horticultural export companies. In general, the share of employed households increased over time from 30.3% in 2006 to 42.0% in 2013. This is explained by the fact that after 2006 new horticultural export companies invested in the Senegal River Delta and created more jobs in the region. The employment duration per year increased over time as well; workers are hired on average 136 days in 2006 and 163 in 2013, but employment in the horticultural export companies remains mainly seasonal. The majority is hired on a daily basis (61.2%), while seasonal (11.2%) and yearly (27.7%) contracts are also common. Average daily wages did not change over time, but wages are 66.7% higher than the national minimum wage of 1,500 FCFA per day. Employees perform jobs that require few skills; they work on the fields for harvesting and weeding, or in the plants for washing, sorting, and packing of the produce.

(iv) Development of a rural nonfarm economy

Not only horticultural export companies created employment opportunities in the region, the labor market in general has evolved and a rural service sector has emerged subsequent to the horticultural export boom. Mainly households of LStransition (51%) and LS-wage (24%) are employed in the service sector and their income derived from this sector increased tremendously over time; from 71,000 FCFA in 2006 to 902,000 FCFA in 2013 for LS-transition, and from 227,000 FCFA to 436,000 FCFA for LS-wage. The demand for jobs in the service sector has grown as income of rural households increased. Table 5 describes some characteristics of employment in this sector. The jobs in this sector are highly heterogeneous, as they comprise both low-skilled professions, such as domestic workers, hairdressers, and garment-workers, and high-skilled professions, such as teachers and civil servants. The jobs are partially performed in Saint-Louis town and the more urbanized villages that are closely located to Saint-Louis town. On average, the share of employed households as well as the number of workers per household increased, illustrating the growing importance of the service sector in the Senegal River Delta. Wages earned in this sector are quite high and increased from 3,000 FCFA per day on average in 2006 to almost 5,000 FCFA in 2013, but they vary substantially across professions, as indicated by the high standard error. A large difference with employment in the horticultural export sector is that workers are nearly year-round employed.

Also employment in own off-farm businesses increased among rural households in the Senegal River Delta. The share of households involved in self-employment did not change over time in the area (53% in 2006 and 51% in 2013), but the income from self-employment increased modestly in all LS categories, except for LS-wage. The increase was most important for households of LS-livestock; revenues from offfarm self-employment increased from 493,000 FCFA (33% of total household income) to 773,000 FCFA (52% of total household income). Also households of LS-wage were able to raise their revenues from self-employment and the share of households with own businesses in this category increased from 38% to 80%. This suggests some spill-over effects whereby wages earned in off-farm employment are invested in own businesses with a relatively high return. Contrary, the income from self-employment for households in category LS-transition decreased substantially (from 509,000 FCFA to 174,000 FCFA), and the share of households involved in self-employment decreased from 61% to 27%. These households likely moved from less remunerative off-farm businesses into wage employment. Off-farm self-employment includes a variety of businesses, mainly services, such as petty trading, construction works, and taxi services. These businesses are mainly located within the villages or along the roads. Some of these businesses are directly linked to the horticultural companies and associated employment, such as food and drink stalls serving employees at the company gates, and transport services from and to the companies.

(v) Migration and remittances

Migration is to some extent part of households' LS in the research area, as household members move out of their rural villages in search of non-farm jobs in urban and peri-urban areas or abroad. Non-labor income consists mainly of remittances (53% in 2006 and 74% in 2013) and has increased over time for all LS. The share of remittances in total household income is largest for LS-crop, which is the category with the lowest income growth and poverty reduction. Unfortunately our data are not detailed enough to describe migration destinations and reasons, and to establish a better link between members leaving the household and households receiving remittances.

Table 5. Characteristics of employment in horticultural export companies and in the service sector

	Employment in horticultural export companies		Employment in service sector		
	2006	2013	2006	2013	
Share of employed households ¹ (%)	30.28	41.98***	10.46	25.24***	
Number of workers per employed household ²	3.15	2.12***	1.15	1.51**	
	(0.22)	(0.14)	(0.09)	(0.11)	
Number of days employed per worker ²	135.99	163.22***	215.35	244.98	
	(7.39)	(6.75)	(19.25)	(13.00)	
Daily wage (FCFA/day)	2,537	2,550	3,002	4,982**	
	(88.00)	(91.00)	(409.00)	(556.00)	

Significant differences are indicated with $p^* < 0.1$, $p^* < 0.05$, or $p^{***} < 0.01$. Standard errors are reported between parentheses for continuous variables. ¹Population statistics are derived using sampling weights.

²Conditional on being employed.

6. DISCUSSION

Our findings point to complementarities between structural transformation and agricultural transformation-or between farm and non-farm activities-and between small-scale and large-scale farming-or between self-employment and wage employment in agriculture. Investments in both the agricultural and non-agricultural sector and in both small-scale and large-scale farming have stimulated rural development and poverty reduction in the Senegal River Delta region. We show that poverty in our sample reduced with 19.2 pp over the period 2006–13. Our results imply that about 9.0 pp poverty reduction comes from LS-crop (15 pp poverty reduction among 47% of the sample) and LS-livestock (18 pp poverty reduction among 11% of the sample), and is associated with small-scale agriculture, livestock rearing, and non-farm businesses. Likewise, about 10.2 pp poverty reduction comes from LS-transition (40 pp poverty reduction among 20% of the sample) and LS-wage (9 pp poverty reduction among 22% of the sample), and is associated with large-scale farming and farm and non-farm wage employment. Household income growth and poverty reduction has been most impressive for households moving into wage employment on large-scale farms and in service sectors. Income growth in small-scale agriculture has been more modest but has affected the largest number of households.

(a) Structural and agricultural transformation

Both structural and agricultural transformation have driven income growth and poverty reduction in the Senegal River Delta region. On the one hand, our findings support the statements formulated by researchers (e.g., Collier & Dercon, 2014; Rigg, 2006; van Vliet *et al.*, 2015) and policy makers (e.g., IFAD, 2016; IFPRI, 2015) that resource-poor smallholders with low farm profit potential should move out of smallholder agriculture in order to move out of poverty. We find that households who moved into wage employment had fewer farm assets (less land and livestock) but more family labor and have experienced the sharpest income growth and poverty reduction, indicating that moving out is indeed a valid strategy to escape poverty for resource-poor households. However, such a moving-out strategy is importantly determined by household location close to employment opportunities.

On the other hand, our findings imply that rather than the development of a rural non-farm economy, the development of a rural labor market has been crucial for income growth and poverty reduction in the Senegal River Delta region. Moving out of smallholder farming does not necessarily imply investing in non-farm activities or migrating to urban areas but can also imply entering jobs on large-scale farms and in non-farm businesses. According to Haggblade et al. (2010), there are two conditions for the rural non-farm economy to contribute to pro-poor growth: the non-farm sector must be growing robustly and the poor must have access to nonfarm jobs in the sector. These two conditions have been met in the Senegal River Delta region, not in the non-farm sector but in the horticultural export sector. This labor-intensive sector expanded rapidly over the past decade and has created jobs, agricultural as well as non-agricultural jobs, that require few skills and are accessible for poorer households.

Our results do not support the idea that migration of households from rural to urban areas is a fundamental component of structural transformation and economic growth (Collier & Dercon, 2014). While income from remittances sent by household members who moved to urban areas has been growing over time, migration has not been a major driving force of income growth and poverty reduction in the Senegal River Delta. The expansion of employment opportunities within the area, arising from the expansion of the horticultural export sector and the subsequent development of a rural service sector, might have discouraged migration to larger cities. Our findings support the results of Christiaensen and Todo (2014) that moving out of smallholder agriculture but remaining in rural areas or secondary towns results in more inclusive growth patterns and faster poverty reduction than agglomeration in mega cities.

(b) Large- and small-scale farming

Agricultural transformation and poverty reduction in the Senegal River Delta have been driven by both the smallholder sector and the large-scale farm sector. Expansion of the largescale horticultural export sector has resulted in rapid income growth and poverty reduction through employment creation, and has played a major role in the development process of the area. Horticultural export production is realized through intensified farming with advanced irrigation techniques, modern equipment and machinery, improved seeds, and deliberate agro-input application; and results in high yields of crops with a high intrinsic and export value. The sector is vertically integrated with production, processing, and transport handled within the ownership structure of the export companies. The importance of the horticultural export sector in our research area, is to some extent in line with the view of Collier and Dercon (2014) that investments in large-scale commercial farming and vertically integrated enterprises entail the highest potential for pro-poor agricultural-led growth.

Yet, we find that the smallholder farm sector has been important in contributing to poverty reduction as well. No important productivity increases emerged in small-scale crop production and livestock rearing but farm incomes increased as a result of public investments in irrigation and consequent rice area expansion, price increases, and herd size expansion. The huge increase in rice prices has importantly boosted farm incomes but mainly resulted from international market price fluctuations and less from quality and supply chain upgrading. Despite the efforts of the government to render Senegal selfsufficient in rice production, the country remains a net rice importer and international price spikes have mainly lowered purchasing power of consumers. Rice producers in our research area have gained from international price increases but they remain vulnerable to downward price trends and shocks. Therefore further investments in the rice sector-particularly investments resulting in productivity increases, quality upgrading, or value chain development-remain crucial for income growth and poverty reduction in the Senegal River Delta. This is in line with statements by Christiaensen et al. (2011) and Larson et al. (2016) that enhancing agricultural productivity remains critical in designing effective poverty reduction strategies for rural areas. Our results imply that this remains true for a region where almost half of the population managed to enter off-farm jobs.

(c) Potential linkages and growth multiplier effects

While we do not directly address intersectoral linkages, our livelihood strategy approach reveals that there are large complementarities between farm and non-farm sectors, and between small- and large-scale sectors. It has been demonstrated that forward and backward production linkages between the agricultural sector on the one hand and agroinput and food-processing industries on the other hand have been particularly important in creating overall economic growth from agricultural transformation at the time of the Green Revolution in Asia (Haggblade *et al.*, 1998). In our research area the development of the horticultural export sector entails some forward production linkages between horticultural production and food processing but expenditure linkages have likely been more important in creating income growth. These expenditure linkages can include both investment and consumption linkages and linkages between both the farm and the non-farm sector and the large- and smallscale farm sector.

First, the wages rural households earn as employee in largescale horticultural export companies can be (partially) invested in households' own farm and non-farm businesses. Off- and non-farm wages are frequently observed to serve as finance for agricultural input purchases when rural credit markets are weak (Adjognon, Liverpool-Tasie, & Reardon, 2017); and such investment linkages have been observed in other horticultural export areas in Senegal by Maertens (2009). While some argue that investment linkages can only be exploited by relatively better-off rural households (Alobo Loison, 2015; Oya, 2013), we observe that households with less land and livestock endowments take up jobs in horticultural companies and subsequently invest in small-scale non-farm businesses. Second, the wages rural households earn as employee in large-scale horticultural export companies importantly add to household income for a large share of rural households. These increased rural incomes can boost the demand for locally produced farm and non-farm goods and services, and stimulate both the rural farm and non-farm economy. In our research area, the growth in rural non-farm businesses and non-farm wage employment in the service sector following the horticultural export boom, likely partially stems from consumption and investment linkages.

This is in line with earlier observations that in SSA expenditure linkages are more important than production linkages in creating growth multiplier effects (e.g., Diao et al., 2010; Wiggins et al., 2010). The development of a rural labor market-resulting in households staying in rural areas and secondary towns while participating in the labor market instead of moving to urban areas-may contribute importantly to creating expenditure linkages and growth multiplier effects. Our results imply that agriculture-led growth is particularly strong when small- and large-scale sectors (or export and staple food sectors) co-exist. Important prerequisites for such a coexistence are that land acquisition occurs through a transparent, clear process and that competition for land and water is minimal (Deininger & Byerlee, 2012). These prerequisites have been met in the Senegal River delta, as land and water are (currently) relatively well available and land lease deals are arranged at the rural community level, rather than being imposed top-down from the national level.

7. CONCLUSION

Development in the Senegal River Delta region in northern Senegal has been remarkably pro-poor. We find that over the period 2006–13, average household income in the region grew with 4.3% annually, poverty reduced with 29.5 percentage points, extreme poverty with 13.4 percentage points and inequality with 4.2 percentage points. Poverty and inequality decreased much more rapidly than in Senegal and Sub-Saharan Africa in general. About 55% of households in the region remained in smallholder agriculture combined with small-scale non-farm businesses, while about 45% moved into wage employment on large-scale horticultural export farms and in service sectors. Household income growth and poverty reduction has been most impressive for households moving into wage employment. Income growth in small-scale agriculture and non-farm businesses has been more modest but has affected the largest number of households.

Our findings imply that both structural and agricultural transformation have driven rural development in the Senegal River Delta region, and that private and public investments in both large-scale and small-scale agriculture have contributed importantly to household income growth and poverty reduction. Our results support the view that moving out of smallholder agriculture is a good strategy to rapidly escape poverty for resource-poor households but at the same time hold up the position that moving up in smallholder agriculture leads to growth and poverty reduction as well, albeit at a slower pace. Our results show that (foreign) investments in large-scale commercial and export-oriented farming can trigger pro-poor growth-directly through employment effects and indirectly through investment and consumption linkages with the small-scale farm and nonfarm sector. This is in sharp contrast with the view that globalization increases inequality and with the idea that food export sectors need to be smallholder based in order to contribute to poverty reduction. This finding implies that the development of a rural labor market is crucial-whether employment is created from investments in agricultural or non-agricultural sectors is likely less important-and that growth effects might be strongest where large-scale and small-scale sectors co-exist.

Our findings are obviously specific for our study region, which complicates drawing more general conclusions. Land and water are relatively well accessible and the region succeeded in attracting substantial foreign investments in horticultural export production. Effects might differ in other regions where the conditions for expansion of a large-scale farm sector differ. In regions where demographic growth creates pressure on land and other resources, expansion of a large-scale sector might limit growth in the smallholder sector and result in less inclusive growth (Losch, Fréguin-Gresh, & White, 2012). Our case-study area is a rather small region around the major horticultural export companies. Positive income effects from employment in these companies, and eventual growth multiplier effects from investment and consumption linkages, likely fade away with larger distance from this core investment area. In addition, we mostly focus on monetary income and poverty measures at the household level, and do not (or only very briefly) consider non-monetary dimensions of wellbeing and intra-household livelihood issues. Nevertheless, in-depth insights from this success-story of rural income growth and poverty reduction may perhaps advance the debate on rural development in Sub-Saharan Âfrica.

NOTES

1. Poverty headcount ratio is based on \$1.90 a day (2011 PPP).

2. The same questionnaire was used in both survey rounds but less relevant modules were dropped in the second survey round while some potentially relevant modules were added.

3. The national currency FCFA stands for *Franc Communauté Financière* $d^{\prime}Afrique$ and has a fixed exchange rate to the Euro: $\notin 1$ is 655.957 FCFA.

4. These numbers represent population statistics and are calculated using sampling weights. The share of poor households in the sample decreased from 54.1% to 34.9%—a reduction of 19.2 percentage points (pp)—and the share of extremely poor households from 30.6% to 23.94%—a reduction of 6.7 pp.

5. Incidence of poverty/extreme poverty is measured as the percentage of the population living on less than \$3.10 a day/\$1.90 a day at 2011 international prices.

REFERENCES

- Adjognon, S. G., Liverpool-Tasie, S., & Reardon, T. (2017). Agricultural input credit in Sub-Saharan Africa: Telling myth from facts. *Food Policy*, 67, 93–105.
- Aksoy, M. A., & Beghin, J. C. (Eds.) (2004). *Global agricultural trade and developing countries*. Washington, DC: World Bank.
- Alkire, S., & Santos, M. E. (2010). Acute multidimensional poverty: A new index for developing countries. In *Human development research* paper 11. New York: UNDP.
- Alobo Loison, S. (2015). Rural livelihood diversification in sub-saharan Africa: A literature review. *The Journal of Development Studies*, 51(9), 1125–1138.
- Andersson Djurfeldt, A., & Djurfeldt, G. (2013). Structural transformation and African smallholders: Drivers of mobility within and between the farm and non-farm sectors for eight countries. Oxford Development Studies, 41(3), 281–306.
- Ansoms, A., & McKay, A. (2010). A quantitative analysis of poverty and livelihood profiles: The case of rural rwanda. *Food Policy*, 35, 584–598.
- Babulo, B., Muys, B., Nega, F., Tollens, E., Nyssen, J., Deckers, J., et al. (2008). Household livelihood strategies and forest dependence in the highlands of Tigray, Northern Ethiopia. Agricultural Systems, 98, 147–155.
- Barrett, C. B., Reardon, T., & Webb, P. (2001). Nonfarm income diversification and household livelihood strategies in rural Africa: Concepts, dynamics, and policy implications. *Food Policy*, 26, 315–331.
- Byerlee, D., de Janvry, A., & Sadoulet, E. (2009). Agriculture for development: Toward a New Paradigm. *Annual Review of Resource Economics*, 1, 15–31.
- Carter, M. R., & Barrett, C. B. (2006). The economics of poverty traps and persistent poverty: An asset-based approach. *The Journal of Development Studies*, 42(2), 178–199.
- Christiaensen, L., Demery, L., & Kuhl, J. (2011). The (Evolving) role of agriculture in poverty reduction: An empirical perspective. *Journal of Development Economics*, 96, 239–254.
- Christiaensen, L., & Todo, Y. (2014). Poverty reduction during the ruralurban transformation – The role of the missing middle. World Development, 63, 43–58.
- Collier, P., & Dercon, S. (2014). African agriculture in 50 years: Smallholders in a rapidly changing world?. *World Development, 63*, 92–101.
- Comtrade (2015). UN Comtrade Database.
- Davis, B., Winters, P., Carletto, G., Covarrubias, K., Quiñones, E. J., Zezza, A., et al. (2010). A cross-country comparison of rural income generating activities. World Development, 38(1), 48–63.
- de Mey, Y., Demont, M., & Diagne, M. (2012). Estimating bird damage to rice in Africa: Evidence from the Senegal River Valley. *Journal of Agricultural Economics*, 63(1), 175–200.
- Deininger, K., & Byerlee, D. (2012). The rise of large farms in land abundant countries: Do they have a future?. World Development, 40(4), 701–714.
- Delgado, C., Hopkins, J., & Kelly, V. (1998). Agricultural growth linkages in sub-saharan Africa. Research report 107. Washington, DC: IFPRI.
- Demont, M., & Rizzotto, A. C. (2012). Policy sequencing and the development of rice value chains in Senegal. *Development Policy Review*, 30(4), 451–472.

- Dercon, S. (2009). Rural poverty: Old challenges in new contexts. World Bank Research Observer, 24, 1–28.
- Dercon, S., & Gollin, D. (2014). Agriculture in African development: Theories and strategies. *Annual Review of Resource Economics*, 6(1), 471–492.
- Diagne, M., Demont, M., Seck, P. A., & Diaw, A. (2013). Self-sufficiency policy and irrigated rice productivity in the Senegal River Valley. *Food Security*, 5, 55–68.
- Diao, X., & Dorosh, P. (2007). Demand constraints on agricultural growth in east and Southern Africa: A general equilibrium analysis. *Development Policy Review*, 25(3), 275–292.
- Diao, X., & Hazell, P. (2004). Exploring market opportunities for African smallholders. 2020 Africa conference brief 6. Washington, DC: IFPRI.
- Diao, X., Hazell, P., & Thurlow, J. (2010). The role of agriculture in African development. *World Development*, 38(10), 1375-1383.
- Dorosh, P., & Thurlow, J. (2016). Beyond agriculture versus nonagriculture: Decomposing sectoral growth-poverty linkages in five African countries. *World Development (forthcoming)*. http://dx.doi. org/10.1016/j.worlddev.2016.08.014.
- Dorward, A., Anderson, S., Nava Bernal, Y., Sánchez Vera, E., Rushton, J., Pattison, J., *et al.* (2009). Hanging in, stepping up and stepping out: Livelihood aspirations and strategies of the poor. *Development in Practice*, 19(2), 240–247.
- Ellis, F. (2000). *Rural livelihoods and diversity in developing countries*. Oxford: Oxford University Press.
- Ellis, F. (2005). Small farm, livelihood diversification, and rural-urban transitions: Strategic issues in sub-Saharan Africa. In: The future of small farms, research workshop proceedings, Wye, UK, June 26–29, 2005 (pp. 135–149).
- Haggblade, S., Hazell, P., & Brown, J. (1998). Farm-nonfarm linkages in rural Sub-Saharan Africa. World Development, 17(8), 1173–1201.
- Haggblade, S., Hazell, P., & Reardon, T. (2010). The rural non-farm economy: Prospects for growth and poverty reduction. *World Development*, 38(10), 1429–1441.
- International Food Policy Research Institute (2015). 2014–2015 global food policy report. Washington DC: IFPRI.
- International Fund for Agricultural Development (2016). Rural development report 2016: Fostering inclusive rural transformation. Rome: IFAD.
- International Monetary Fund (2015). International Financial Statistics Public Data.
- Irz, X., Lin, L., Thirtle, C., & Wiggins, S. (2001). Agricultural productivity growth and poverty alleviation. *Development Policy Review*, 19(4), 449–466.
- Jansen, H. G. P., Pender, J., Damon, A., Wielemaker, W., & Schipper, R. (2006). Policies for sustainable development in the hillside areas of honduras: A quantitative livelihoods approach. *Agricultural Eco*nomics, 34, 141–153.
- Kakwani, N., & Pernia, E. (2000). What is pro-poor growth?. Asian Development Review, 16(1), 1-22.
- Larson, D. F., Muraoka, R., & Otsuka, K. (2016). Why African rural development strategies must depend on small farms. *Global Food Security*, 10, 39–51.
- Lewis, W. A. (1954). Economic development with unlimited supply of labor. *The Manchester School*, 22, 139-91.

WORLD DEVELOPMENT

- Liao, C., Barrett, C., & Kassam, K. (2015). Does diversification improve livelihoods? Pastoral households in Xinjiang, China. *Development and Change*, 46(6), 1302–1330.
- Losch, B., Fréguin-Gresh, S., & White, E. T. (2012). Structural transformation and rural change revisited: Challenges for late developing countries in a globalizing world. African development forum series. Washington DC: World Bank.
- Maertens, M. (2009). Horticulture exports, agro-industrialization, and farm-nonfarm linkages with the smallholder farm sector: Evidence from Senegal. Agricultural Economics, 40, 219–229.
- Maertens, M., Colen, L., & Swinnen, J. (2011). Globalization and poverty in Senegal: A worst case scenario?. *European Review of Agricultural Economics*, 38(1), 31–54.
- Maxwell, S., & Slater, R. (2003). Food policy old and new. Development Policy Review, 21(5-6), 531-553.
- Mellor, J. W., & Malik, S. J. (2017). The impact of growth in small commercial farm productivity on rural poverty reduction. *World Development*, 91, 1–10.
- Oya, C. (2013). Rural wage employment in Africa: Methodological issues and emerging evidence. *Review of African Political Economy*, 40(136), 251–273.
- Petrovici, D. A., & Gorton, M. (2005). An evaluation of the importance of subsistence food production for assessments of poverty and policy targeting: Evidence from Romania. *Food Policy*, 30, 205–223.
- Rahman, S., & Akter, S. (2014). Determinants of livelihood choices: An empirical analysis from rural Bangladesh. *Journal of South Asian Development*, 9(3), 287–308.
- Ravallion, M., & Chen, S. (2003). Measuring pro-poor growth. *Economics Letters*, 78, 93–99.
- République du Sénégal (2012). Rapport Introductif du Conseil Interministériel sur le Développement de la Riziculture.
- République du Sénégal (2014). Evaluation Quantitative du DSRP-II: Dynamique de la Pauvreté Monétaire.
- Rigg, J. (2006). Land, farming, livelihoods and poverty: Rethinking the links in the rural south. *World Development*, 34(1), 180–202.
- Rodenburg, J., & Johnson, D. E. (2009). Weed management in rice-based cropping systems in Africa. Advances in Agronomy, 103, 149–218.
- Rosegrant, M. W., Paisner, M. S., Meijer, S., & Witcover, J. (2001). Global food projections to 2020: Emerging trends and alternative futures. Washington DC: IFPRI.

T 11 (01

- Ruttan, Y., & Hayami, V. W. (1971). Agricultural development: An international perspective. Baltimore MD: John Hopkins Press.
- Sakurai, T. (2016). On the determinants of high productivity rice farming in irrigated areas in Senegal: The efficiency of large compared with small-scale irrigation schemes. In K. Otsuka, & D. F. Larson (Eds.), *In pursuit of an African green revolution* (pp. 119–143). Japan: Springer.
- Schultz, T. W. (1964). *Transforming traditional agriculture*. New Haven: Yale University Press.
- Swinnen, J. (2007). Global supply chains, standards and the poor. Cambridge: Cab International.
- Tanaka, A., Diagne, M., & Saito, K. (2015). Causes of yield stagnation in irrigated lowland rice systems in the Senegal river valley: Application of dichotomous decision tree analysis. *Field Crops Research*, 176, 99–107.
- van den Berg, M. (2010). Household income strategies and natural disasters: Dynamic livelihoods in rural Nicaragua. *Ecological Eco*nomics, 69, 592–602.
- Van den Broeck, G., Swinnen, J., & Maertens, M. (2017). Global value chains, large-scale farming, and poverty: Long-term effects in Senegal. *Food Policy*, 66, 97–107.
- van Vliet, J. A., Schut, A. G. T., Reidsma, P., Descheemaeker, K., Slingerland, M., van de Ven, G. W. J., *et al.* (2015). De-mystifying family farming: Features, diversity and trends across the globe. *Global Food Security*, 5, 11–18.
- Wiggins, S., Kirsten, J., & Llambí, L. (2010). The future of small farms. World Development, 38(10), 1341–1348.
- World Bank (2007). World development report 2008: Agriculture for development. Washington DC: World Bank.
- World Bank (2015). World Development Indicators.

APPENDIX A.

Table 6. Cluster analysis of alfferent livelinood strategies									
Livelihood strategy	1	1 2 3			4				
	Crop pro	duction	Livesto	ck and	Transit	ion to	Wa	ge	
	and s	self-	self-empl	oyment	Wa	ge	employ	ment	
	employ	ment			employ	ment			
Number of observations	121	47%	28	11%	51	20%	55	22%	
	Mean	SE	Mean	SE	Mean	SE	Mean	SE	
2006									
Share of workers involved in crop production	0.59	0.04	0.29	0.07	0.17	0.04	0.27	0.05	
Share of workers involved in livestock	0.12	0.02	0.31	0.05	0.08	0.03	0.16	0.03	
Share of workers involved in self-employment	0.17	0.02	0.40	0.06	0.40	0.06	0.36	0.06	
Share of workers involved in wage employment	0.32	0.03	0.14	0.05	0.19	0.03	0.62	0.04	
Share of time involved in crop production	0.12	0.02	0.18	0.04	0.03	0.01	0.08	0.02	
Share of time involved in livestock	0.12	0.03	0.70	0.08	0.13	0.05	0.29	0.06	
Share of time involved in self-employment	0.28	0.04	0.70	0.07	0.44	0.06	0.36	0.06	
Share of time involved in wage employment	0.27	0.03	0.14	0.05	0.32	0.05	0.83	0.03	
2013									
Share of workers involved in crop production	0.40	0.03	0.17	0.06	0.07	0.02	0.19	0.04	
Share of workers involved in livestock	0.07	0.01	0.67	0.05	0.02	0.01	0.11	0.02	
Share of workers involved in self-employment	0.24	0.03	0.33	0.05	0.06	0.01	0.24	0.02	
Share of workers involved in wage employment	0.10	0.02	0.20	0.04	0.48	0.04	0.49	0.03	
Share of time involved in crop production	0.37	0.03	0.09	0.03	0.09	0.02	0.16	0.03	
Share of time involved in livestock	0.16	0.03	0.75	0.04	0.05	0.02	0.38	0.05	
Share of time involved in self-employment	0.49	0.04	0.73	0.08	0.16	0.04	0.72	0.05	
Share of time involved in wage employment	0.15	0.02	0.38	0.08	0.78	0.04	0.79	0.03	

Source: own elaboration.

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Livelihood strategy	Crop proc self-em	duction and ployment	Livestock and self- employment		Transition to wage employment		Wage employment	
	Mean	St.Dev.	Mean	St.Dev.	Mean	St.Dev.	Mean	St.Dev.
Wolof ethnicity	61%		14%		59%		35%	
Peulh ethnicity	19%		21%		18%		55%	
Maure ethnicity	12%		54%		16%		4%	
2006								
Age of HH head	56.89	12.41	55.89	12.58	58.10	11.52	57.91	12.20
Female HH head	4%		4%		4%		4%	
HH head education	16%		14%		25%		33%	
HH size	14.79	9.60	16.82	20.06	16.31	9.36	16.45	8.97
Dependency ratio	0.57	0.15	0.56	0.16	0.57	0.14	0.57	0.16
Total land	1.89	4.74	1.77	3.28	1.00	1.80	1.58	2.57
Total livestock units	4.54	12.45	15.55	25.15	0.91	1.76	4.39	9.77
2013								
Change of HH head	9%		7%		14%		13%	
Age of HH head	58.65	13.92	55.00	14.95	58.57	14.01	61.04	12.62
Female HH head	9%		14%		8%		13%	
HH head education	16%		21%		39%		42%	
HH size	10.32	4.81	8.46	3.66	11.43	5.93	13.18	6.79
Dependency ratio	0.52	0.16	0.57	0.17	0.49	0.16	0.50	0.12
Total land	3.86	12.08	1.32	2.05	1.20	2.50	1.85	2.52
Total livestock units	2.18	5.03	20.62	20.43	1.42	6.03	3.60	8.98

Table 7. Socio-economic characteristics of different livelihood strategies for 2006 and 2013

Source: own elaboration.

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