



## Feasibility Study for Development of Cashew-Based Farming Operations in Vichada

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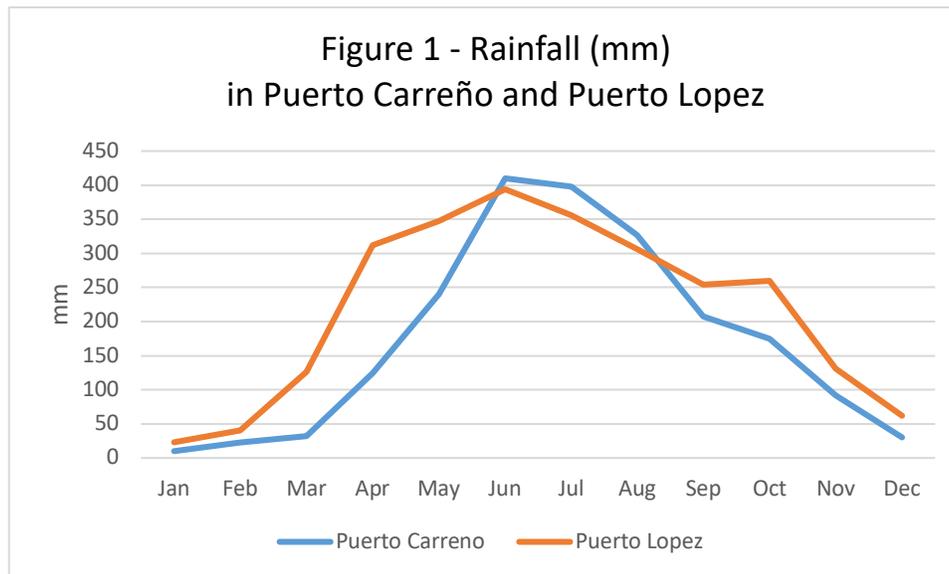
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**Introduction** – The economic development of Vichada is constrained by a small labor force and high transport costs (Department of Vichada, 2016). The total population of the Department is estimated at 75,468 (Dane, 2017). If the labor force participation in 2016 of Puerto Carreño of 66.2% is representative, the total labor force for the department is only about 50,000. Vichada has only a few kilometers of hard surfaced road, mostly streets in the capital Puerto Carreño. In 2012 there were only 1.14 km of paved interurban highway in the department. There is no highway connection to the rest of Colombia. Also, there is no railroad connection of any kind. River transport is often cited as the best option for Vichada, but the Meta River link to Puerto Gaitan is only usable during the high-water period of the rainy seasons. Because Meta River transport is slow and subject to many uncertainties, it is used mainly for durable goods. The main exception is the shipment of about 30,000 cattle annually by river to markets in Meta Department. The Orinoco River is navigable throughout the year, but because of political disagreements with neighboring Venezuela, the Orinoco is seldom used for shipping.

The departmental development plan highlights agriculture as an area of entrepreneurial opportunity (Department of Vichada, 2016). The Instituto Geográfico Agustín Codazzi (IGAC) has estimated that of the department's 10,017,775 hectares, 3.6 million are suitable for agriculture, forestry and livestock grazing. In the 2013-2014 agricultural census 6,565 farms were reported in Vichada. About 9% of those farms are over 1000 hectares and those large farms control 95% of the department area. About 73% of the farms are under 50 hectares, but those smaller farms control less than 1% of the department area. The primary agricultural land use in the department is extensive

pasture for cattle. In 2012 only 22,261 hectares were cropped, including production of cacao, rice, cotton, plantain, maize and cassava. Soils are sandier than in the Meta Altillanura, acidic, high aluminum and have low nutrient levels. Average annual rainfall in Puerto Carreño is about 2000 mm/year, compared to about 2600 mm annually in Puerto Lopez in the Meta Altillanura. In Vichada the dry season is drier and slightly longer than in Meta (Figure 1).



Source: <https://en.climate-data.org/>

**Modifying the Meta Altillanura model** – The starting point for the Vichada Altillanura analysis is the Meta Altillanura baseline model. Climate, soils and crops are similar. To identify potential agricultural opportunities Purdue researcher J. Lowenberg-DeBoer visited Vichada in January and in September 2017. Based on those discussions and secondary information the following activities were dropped from the Vichada model: annual grain crops (i.e., rice-soybean, corn-soybean, crop-beef, cattle finishing and beef silage). Many crops and livestock species could be grown in Vichada, but local markets are small and transport costs are very high to markets in other parts of Colombia or for export. The ideal farm product for Vichada has a high value to weight ratio, so as to better support the transportation costs.

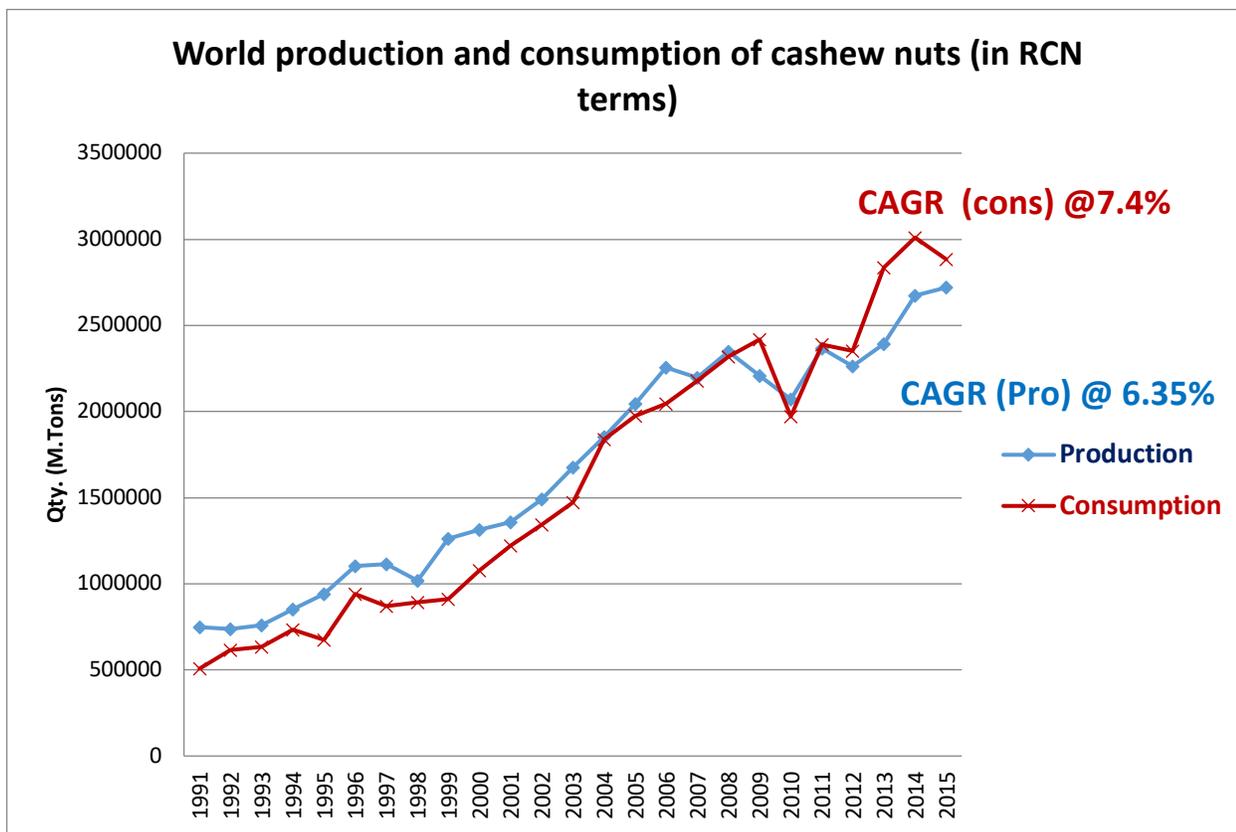
To adjust for the impact of higher transport costs on farm product prices in Vichada, 200 CoP/kg or 200,000 CoP/ton was deducted from the Meta Altillanura model prices. For oil palm, the price in the model is given in terms of Fresh Fruit Bunches (FFB), but it is the crude palm oil (CPO) that is transported. Most agreements in the Altillanura establish the price of FFB at about 18% of the CPO price. Consequently, 18% of the 200 CoP/kg transport costs was deducted from the FFB price for Vichada.

Many contacts in Vichada pointed to cashew as a growing agricultural opportunity. Cashews grow very well in the sandy soil of Vichada. Cashews flower during the dry season and the slightly

longer dry season in Vichada can permit an additional cycle of flowering/fruiting. Until now the bottleneck has been processing. There is no industrial processing of cashew in the department and artisanal processors only have a few tons per year. It should be noted that cashew processing is complicated because of the caustic substances, cardol and anacardic acid, which occur in the inner lining between their two shell layers. Cashew processing workers often suffer from skin and eye irritation and burns. There are currently about 1500 ha of cashew plantations in Vichada. Most of cashew trees in Vichada have been neglected, some have been abandoned, because of the lack of a market. There is small scale cashew processing in Bucaramanga and Fontibón Bogotá, but the cost of transporting the raw nuts makes it unprofitable for most growers to harvest and ship their product there. Developing cashew processing in Vichada is key to growing the cashew industry there. The commitment of DML Produce from Cali to start buying cashew nuts in Puerto Carreño is a game changer. DML has links to the European snack food manufacturer August Töpfer & Company (ATCO - <http://www.atco.de/home-3/>) and plans to build a cashew processing plant in Puerto Carreño when the scale of production has increased. According to Jairo Gomez, CEO of DML, the threshold scale for industrialized cashew processing is 7500 tons of RCN annually.

The cashew kernel is about 25% of the weight of raw cashew nuts (RCN). Once the cashew nut is processed, it becomes the almost perfect product to prosper in the high transport cost Vichada economy. Cashew nuts are a high value to weight product. The most economical transportation for the nuts would be by river, either down the Orinoco to sea ports or up the Meta to Puerto Lopez in the rainy season, but the industry could be profitable even if the nuts had to be shipped by air. Artisanal producers in Puerto Careño now ship some of their product by air.

Worldwide cashew demand has been growing at over 7% annually (Figure 2). Production is growing at about 6% (Bhoodes, 2017). Cashew nuts originated in the Amazon basin. The cashew genetics that have spread around the world originated in Brazil, but the trees grow wild throughout the Amazon basin, including in Colombia. Currently over 40% of RCN production is in Africa ([www.cashewinfo.com](http://www.cashewinfo.com), 2014). Cote d'Ivoire produces 18% of global production. Another 29% is produced in India and 10% in Vietnam. Brazil grows about 5% of worldwide cashew production and processes mostly domestic production. Most industrial cashew processing is in India and Vietnam. Most of the African RCN is exported to India and Vietnam for processing. Demand is growing in part because nuts in general are seen as health foods, and cashews are considered a premium product. Some projections predict a doubling of cashew demand by 2025 (Adzanyo et al, 2016).



Source: Bhoodes, CEPI, 2017

**Figure 2.** World cashew production and consumption

Colombia currently produces a small amount of cashew. In 2014, the total area planted to cashew in the country was 3,150 ha (Uniandes et al, 2015) with almost half of that total in Vichada. Very little of the Colombia cashew area is intensively managed, and yields are low, 20 kg/ha to 40 kg/ha, compared to 1 ton per hectare with conventional management, 2 tons with more intensive management and experimentally 4.5 tons/ha. Almost all of the Colombian domestic cashew production is processed in the country. In addition to domestically produced cashew Colombia imports around 100 tons of cashew per year. Total Colombian domestic cashew demand is estimated at about 300 tons per year. The Colombian opportunity to develop cashew production and marketing was strongly supported by a study led by Uniandes and completed in 2016 (Uniandes et al., 2016). The Uniandes study focused on import substitution potential to meet domestic demand.

**A cashew production activity** – A cashew activity was specified using data from the Uniandes study, complemented by information from cashew growers in Vichada. The total planting costs for cashew is about 2,350,000 CoP/ha (Table 1). Annual production costs are about 235,610 pesos/ha, with most of the expenditure occurring with fertilization and pruning in November and December in preparation for the fruiting season in January and February (Table 2). Labor for production is less than 9 days per hectare with most of the labor concentrated in the pre-harvest and harvest period (i.e. November to February).

**Table 1.** Cashew planting costs

<b>Input or Service</b>	<b>Pesos</b>
<b>Digging holes</b>	35,000
<b>Seedlings</b>	35,000
<b>Transplant</b>	35,000
<b>Tractor for field prep and liming</b>	100,000
<b>Lime, gypsum</b>	1,000,000
<b>Thomas slag</b>	1,050,000
<b>Agricultural gypsum</b>	58,100
<b>Coffee fertilizer</b>	29,880
<b>Micronutrients</b>	6,308
<b>Total</b>	2,349,288

Source: Uniandes et al., 2016

**Table 2.** Monthly cashew production costs after production starts in year 3

<b>Input</b>	<b>Jan</b>	<b>Feb</b>	<b>Mar</b>	<b>Apr</b>	<b>May</b>	<b>June</b>	<b>July</b>	<b>Aug</b>	<b>Sept</b>	<b>Oct</b>	<b>Nov</b>	<b>Dec</b>
<b>Lime, gypsum</b>											12690	12690
<b>Inorganic fertilizer</b>											47584	47584
<b>Weed eater + gasoline</b>					833	833	833	833	833	833		
<b>Herbicide</b>												
<b>Insecticide</b>												
<b>Fungicide</b>												
<b>Buckets for harvest</b>	2200											
<b>Fire break</b>											65,000	
<b>Total</b>	2200	0	0	0	833	833	833	833	833	833	125274	60274

Source: Uniandes et al., 2016

**Table 3.** Monthly cashew labor requirements after production starts in year 3

Process or Input	Jan	Feb	March	April	May	June	July	Aug	Sept	Oct	Nov	Dec
Pruning	0.49	0.49	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Fertilization											0.98	0.98
Weed Control					0.67	0.67	0.67	0.67	0.67	0.67		
Harvest	0.5	0.5										
<b>Total</b>	<b>0.99</b>	<b>0.99</b>	<b>0.1</b>	<b>0.1</b>	<b>0.76</b>	<b>0.76</b>	<b>0.76</b>	<b>0.76</b>	<b>0.76</b>	<b>0.76</b>	<b>1.08</b>	<b>1.08</b>

Source: Uniandes et al., 2016

To focus on the long run comparison, the Orinoquia Initiative farm model is steady state. Consequently, a steady state cashew activity was estimated with a 50-year useful life, the planting costs from Table 1, the direct production costs from Table 2 and the labor requirements from Table 3. The 42,886 pesos direct cost is from that 1/50<sup>th</sup> of a hectare replanting that occurs every year for each hectare of production (Table 4). Likewise, extra 0.6 day/ha in April compared to Table 3 is for that 1/50<sup>th</sup> of a hectare replanting for each hectare of production.

This model focuses on cashew nut production. The cashew nut is the seed of an edible fruit that can be used for juice, preserves or other processed fruit product (Sobhana and Pushpalatha, 2014). There is currently some artisanal processing of cashew fruits in Puerto Carreño. Those artisanal products are air freighted to Bogotá and sold in high value niche markets. In Brazil a high proportion of the cashew fruits are harvested and used, most commonly for juice, but worldwide most cashew fruits are not utilized. In the Vichada case, use of the cashew fruit is a potential opportunity that might be profitable when transport infrastructure is improved and more labor is available.

The RCN price in the model is US\$1/kg or at the current exchange rate about 2,680 pesos/kg. That price is from DML produce which plans to start buying RCN in Puerto Carreño with the 2018 harvest. For comparison, according to the *Cashew Week* newsletter in February, 2017 ([http://www.cashewinfo.com/cashew\\_week/Volume\\_18\\_Issue\\_9.pdf](http://www.cashewinfo.com/cashew_week/Volume_18_Issue_9.pdf)), in Cote d'Ivoire the government minimum farm gate price for RCN is 440 FCFA/kg (about US\$0.71/kg) and most farm gate transactions are slightly above that level at 450 to 550 FCFA/kg (US\$0.72-0.88/kg). According to the Agricultural Non-State Actors Forum (ANSAF) mid-range quality RCN was bringing US\$1.50/kg to \$1.90/kg in Vietnam in October and September 2017 (<http://ansaf.or.tz/cashew/>). Higher quality RCN might bring up to US\$2.20/kg in Vietnam.

**Table 4.** Cashew steady state model parameters

	Labor, person days	Direct Cost, '000 pesos	Yield (tons/ha)
Jan	0.99	2.2	0.5
Feb	0.99	0	0.5
Mar	0.1	0	0
Apr	0.16	42.886	0
May	0.76	0.833	0
Jun	0.76	0.833	0
Jul	0.76	0.833	0
Aug	0.76	0.833	0
Sep	0.76	0.833	0
Oct	0.76	0.833	0
Nov	1.08	125.274	0
Dec	1.08	60.274	0

**Baseline results on Unidad Agricola Familiar (UAF) sized farm with limited labor** – As a starting point for the analysis, baseline farm resources must be specified. This includes land, labor and capital. In Colombia most discussions about farm size involved the concept of the Unidad Agricola Familiar (UAF) which is established by the national government. The UAF in part of Vichada situated between the Meta River and the Tomo River (most of northern Vichada) is 956 hectares to 1294 hectares. This UAF is based on traditional extensive cattle production. With more intensive management it is possible that a farm family could make a living with a small area, but as a starting point this analysis will use the lower end of the UAF range for the region, 956 hectares. The model assumes that this is 956 hectares of usable land without marichal or caños. It is also assumed that the farm family has a house and kitchen garden (i.e., pan coger) outside of this 956 hectares.

Labor is a scarce resource in Vichada. Because the analysis is starting with a UAF sized farm, it should start with UAF sized family labor (i.e., two adult equivalents). In the model family labor is assumed to be compensated from farm profits. The few commercial farms in Vichada (e.g., oil palm, commercial forestry, large cattle ranches) often recruit labor in other parts of Colombia and must pay well above the minimum wage, but a UAF sized farm is likely to rely on local labor sources. To reflect the modest size of the local labor force, the maximum permanent hired labor is limited to 2 adults and temporary (day) labor is limited to 10 days per month. Wages are set near the minimum wage: 50,000 pesos/day for temporary labor and 8,853,604 pesos per year for permanent labor. The 8,853,604 is 12 times the minimum monthly wage of 737,717 pesos. Initial cash is set to 1,000 million pesos and maximum borrowing to 2,000 million pesos. The base model is only rainfed farming because irrigation is rare in Vichada.

The farm product prices are adjusted for the higher transport costs in Vichada. Costs of barge transport to Meta are about 200 pesos/kg. Consequently, the prices of the products carried over from the Meta Altillanura model are: Oil Palm Fresh Fruit Bunches (FFB), 284,000 pesos/ton; rubber, 4,300 pesos/kg; heifers, 3900 pesos/kg; cull cows, 3700 pesos/kg; steers, 4600 pesos/kg; and cacay, 500,000 pesos per ton.

**Cattle only solutions** - Because the UAF was specified based on traditional cattle production, it is useful to have a model solution with only beef production activities (i.e., cow-steer – a cow-calf operation with improved pastures; traditional cow-calf – a cow-calf operation on native savannah). With limited labor, the solution shows the cow-steer activity at 456 hectares and 500 hectares left idle. The maximum two permanent workers are hired. Temporary labor is at the maximum only in April when it is roundup time for cattle operations (i.e., branding and vaccinations). In the steady state all activities are financed out of cashflow. The solution does not draw in initial capital or borrow.

The net return on the UAF sized farm with cow-calf production is 52,424,767 pesos annually, which probably does not even cover the opportunity cost of land ownership. For example, if the land is worth 2.5 million pesos/hectare, then at a 20% opportunity cost of capital the opportunity cost of ownership is 478,000,000 pesos. At a land value of 1 million pesos per hectare the opportunity cost is 191.2 million. The 20% opportunity cost of capital is a common target rate for medium scale agricultural investment in the Orinoquia region. For owner operated farms, if the farm business does not at least cover the opportunity cost of landownership, then there is motivation to sell to someone who will convert it to a higher profit use. This motivation to sell becomes particularly strong when a new generation takes over. The older generation may have been comfortable and satisfied in a low profit farm setting, but the younger generation often has other aspirations.

If more labor is available at minimum wage levels, all the land is used for the cow-calf operation with improved pastures. The binding labor constraint is still in April at roundup time. Net return more than doubles to over 121 million pesos. With higher labor costs (i.e., 2 or 3 times the minimum wage), the amount of land in the cow-calf operation is reduced as labor hiring is cutback.

**Solutions with Intensive Tree Crops** – When oil palm, rubber, cashew and cacay activities are added to the UAF sized farm with limited labor, the solution switches to tree crops (Table 5). Land is allocated mainly to cashew (78 ha) with small areas of rubber and cacay (2.3 and 1 hectare respectively). Eight hundred and seventy-five hectares of the farm is left unused. The shadow price indicates that the cow-calf activity would only need to be slightly more profitable to bring it into the solution. Two permanent workers are hired and temporary labor is at the 10 day/month maximum in November and January for fertilization and harvest of cashew. Some of the permanent labor is idle in April. In the steady state all activities are financed out of cashflow. The solution does not draw in initial capital or borrow.

The net return is 192,379,00 pesos, which would just cover the opportunity cost of land ownership on 1 million pesos per hectare land, without compensation to the two family members working on the farm. With a 100 hectare farm the opportunity cost of landownership would be

50,000,000 pesos with a 2.5 million pesos land price and 20,000,000 pesos with a 1 million pesos land price. With a 100-hectare farm, the opportunity costs of land ownership would be easily covered with money left for the family workers.

**Table 5.** Land allocation and shadow prices when intensive tree crops introduced

	LOWER	LEVEL	UPPER	MARGINAL
NoIr.OilPalm	.	.	1.0000E+5	-6118.722
NoIr.Caucho	.	2.301	1.0000E+5	.
NoIr.Cow_Steer	.	.	1.0000E+5	-14.903
NoIr.Cashew	.	77.539	1.0000E+5	.
NoIr.Cacay	.	0.972	1.0000E+5	.
NoIr.Trad Cow-Calf	.	.	1.0000E+5	-136.732

One criticism of the base solution with three tree crops is that the management may be too complex, especially for family farmers. If rubber and cacay are zeroed out, the solution is 83 ha of cashew. The estimated net return is down to 170,870,000 pesos, which is still enough to cover the opportunity cost of land ownership on 100 ha farm with money left for family living. In the cashew only solution, 2 permanent workers are hired and temporary labor is a binding constraint in November at cashew fertilization time. Permanent workers are only idle in April.

When labor is increased to a maximum of 100 permanent workers and 1000 temporary workers per month at minimum wage levels, the solution has larger areas of the three tree crops: 644 ha of cashew, 255 ha of rubber and 57 ha of cacay. All 100 available permanent workers are hired and temporary hiring is a binding constraint in January for cashew harvest and in July during the heart of the rainy season, when there are few good field days for farm work. The estimated net return is 2,573,374,000 pesos which would easily cover the opportunity cost of land ownership with funds available for family labor, hired managers and technical assistance.

If workers need to be recruited from elsewhere at higher wages and the wage rates doubled, the solution still focuses on the same three tree crops but with a higher proportion of cashew. The allocation is 800 ha of cashew, 134 ha of rubber and 21 ha of cacay. With higher wages cashew is the crop of choice because it provides good returns with relatively low labor requirements. Cashew requires 9.86 days per ha/year. Rubber needs 45 days/ha/year and cacay 40.78 days/ha/year. The number of permanent workers is cut to 46, but temporary labor is still at the maximum in January and July. The net return is estimated at 1,810,038,000 pesos, which is still enough to cover the opportunity cost of land ownership at current prices in much of Vichada while allowing for family living cost and management.

If wages must be tripled to attract the necessary workers, the solution tilts even more to cashew, with 882 ha. Rubber is cut back to 8 ha and cacay to 65 ha. Permanent workers are reduced to 35 and temporary labor is only a binding constraint in January during the cashew harvest. The net

return is estimated at 1,329,548,000 pesos, still enough net return to cover the opportunity cost of land ownership, provide family living and pay for management.

The high labor availability solutions represent the case of larger scale investors. If more than a UAF sized farm is available, the solution is increasing large areas of intensively managed tree crops. A major challenge with such large-scale operations in the steady state is attracting adequate labor, but the profitability seems to be high enough to support wages that are several times the minimum wage levels. An even bigger challenge would be supporting the intensive tree crop farm business until it reaches the steady state. Tree crops require several years after planting before any saleable product is produced and additional years before the trees are in full production. Never-the-less, intensively managed tree crops seem to be an opportunity for large scale investors in Vichada.

One other worry expressed by large scale investors in Vichada is that the logistics cost of transporting their products from the farm to Puerto Carreño or other river market would consume the profits. For example, unanticipated logistics cost was one of the key reasons why the Indupalma rubber scheme in Vichada failed. To test the impact of higher logistics cost, the transport cost in the model was doubled. In the baseline solution 200 pesos/kg was deducted for transport. In this solution 400 pesos/kg is deducted. With 100 permanent workers available, 1000 temporary workers per month and wages at three times the minimum wage levels, the land allocation is almost completely cashew. Of the 956 hectares total, 941 are allocated to cashew, with the balance in rubber. Permanent workers number 37 and temporary labor is not a binding constraint. The estimated net return is 1,118,900,000 pesos, which is enough to cover opportunity cost of land ownership, family living and management.

**Commercial Forestry** – One of the new options in Vichada is commercial forestry. The company ForestFirst (<http://www.forestfirst.com/>) is leading the effort on this regard. Their plan is to produce acacia mangium and eucalyptus with the strategy to ship wood chips to Puerto Ordaz on the Atlantic coast in Venezuela via the Orinoco River. The ultimate market is in Europe. They hope to plant 150,000 hectares in Vichada and have already planted 4500. They are developing a “forest services” unit for other land owners in the regions. They hope to help these other land owners plant 35,000 hectares. Currently, 535 hectares of trees are planted on 3<sup>rd</sup> party land. Because labor is difficult to hire in Vichada they have developed a mechanized production system. For example, they have three tree planting machines. They shared some data on their costs and expected production which serves as the basis for a commercial forestry activity in the Vichada analysis. Readers should note that ForestFirst is focused on investor forestry. They do not have experience with or data on forest by medium and small holder family farmers.

Table 6 shows the manual labor needs for a hectare of acacia or eucalyptus. This does not include contractors that drive tractors and other equipment for land preparation, fertilizer spreading, mowing and harvesting. In the ForestFirst system, harvest is to be handled entirely by a contractor for US\$10/m<sup>3</sup>.

The direct cost of forestry is mainly machine services, fertilizer, seedlings, and herbicides. ForestFirst indicates that the planting year direct costs are about US\$1000/ha. For the model this cost was spread evenly over the 12 months of the first year (Table 7), minus the value of the manual labor (Table 6) and plus a 25,000 peso/month technical assistance fee. With an exchange rate of 2680 pesos/US\$ this results in a monthly direct cost of 218,333 pesos. The direct costs in year two to seven are mainly for weed control in the March to July period. This includes mowing charged as the same rate as in year 1 and herbicide at US\$10/kg applied at a rate of 1.5 kg/ha on about 10% of the area each month. In years 2 to 7 the 25,000 peso/month/ha for technical assistance is charged. At an expected yield of 230 m<sup>3</sup>/ha with a harvest cost of US\$10/m<sup>3</sup> spread evenly over 12 months, the expected monthly harvest cost is 804,000 pesos. This harvest pattern may be adjusted because of weather, to fit other crops grown on the farm or other reasons.

**Table 6.** Forestry manual labor needs

	Year 1 days/ha	Yrs. 2-7 days/ha	Harvest - Contractor
<b>Jan</b>	0.6	0.8	0
<b>Feb</b>	0.6	0.8	0
<b>March</b>	0.6	1	0
<b>April</b>	0.6	1	0
<b>May</b>	0.6	1	0
<b>June</b>	0.6	1	0
<b>July</b>	0.6	1	0
<b>August</b>	0.6	0	0
<b>Sept</b>	0.6	0	0
<b>Oct</b>	0.6	0	0
<b>Nov</b>	0.6	0	0
<b>Dec</b>	0.6	0	0

To estimate the steady state parameters, a weighted average was made of the labor and direct cost estimates. With the weight on the first year of 1/7, on years 2 to 7 of 1/7<sup>th</sup> each, and the harvest cost added into the year seven costs. The weighted averages are given in Table 8. The forest steady state labor requirement is between beef production at about 1 day per hectare and cashew at almost 10 days per hectare. The steady state direct costs for forestry using the ForestFirst approach is less than that of oil palm and close to that of cacao.

**Table 7.** Forestry direct cost

	<b>Year 1 days/ha</b>	<b>Yrs 2-7 days/ha</b>	<b>Harvest - Contractor</b>
<b>Jan</b>	218333	25000	804000
<b>Feb</b>	218333	25000	804000
<b>March</b>	218333	252353	804000
<b>April</b>	218333	252353	804000
<b>May</b>	218333	252353	804000
<b>June</b>	218333	252353	804000
<b>July</b>	218333	252353	804000
<b>August</b>	218333	25000	804000
<b>Sept</b>	218333	25000	804000
<b>Oct</b>	218333	25000	804000
<b>Nov</b>	218333	25000	804000
<b>Dec</b>	218333	25000	804000

The estimated output price of wood delivered to the ForestFirst chipping plant planned for somewhere on the Meta River in Vichada, is estimated as the roughly US\$57.50/m<sup>3</sup> of chips in Puerto Ordaz, minus a US\$25/m<sup>3</sup> shipping cost from Vichada to Puerto Ordaz by barge, and at US\$6.50/m<sup>3</sup> transport from the farm to the chipping plant. With an exchange rate of 2680 pesos /US\$, this results in a net price to the producer of about 69,680 pesos/m<sup>3</sup>.

**Table 8.** Forestry GAMS parameters

	<b>Labor</b>	<b>Direct cost</b>
<b>Jan</b>	0.77	149.619
<b>Feb</b>	0.77	149.619
<b>March</b>	0.94	182.098
<b>April</b>	0.94	182.098
<b>May</b>	0.94	182.098
<b>June</b>	0.94	182.098
<b>July</b>	0.94	182.098
<b>August</b>	0.09	149.619
<b>Sept</b>	0.09	149.619
<b>Oct</b>	0.09	149.619
<b>Nov</b>	0.09	149.619
<b>Dec</b>	0.09	149.619
<b>Total</b>	6.69	1958

If an activity with the commercial forestry parameters described above is put into the Vichada base UAF sized family farm analysis with limited labor, the solution shows 86.4 hectares of acacia and eucalyptus and about 2.6 hectares of cacay with the remaining land unused. Two permanent workers are hired and temporary labor is a binding constraint in April. Some permanent labor is idle in the August to December period. In the steady state all activities are financed out of cashflow. The solution does not draw in initial capital or borrow. The estimated net return is 1,214,400,000 pesos which is enough to cover the opportunity costs of owning the land and provide for family living.

In the high labor availability scenario with a maximum of 100 permanent workers and 1000 temporary workers each month, the entire farm is planted to acacia and eucalyptus with two permanent workers and temporary labor hired from January to July. This solution is the same even if wages are 3 times the minimum wage level.

The solutions with commercial forestry show the economic potential of this crop especially for the larger scale investor, but it should be noted that the economic viability depends on being able to ship wood products by barge to Puerto Ordaz in Venezuela. It would not be economic to ship bulky wood products to the rest of Colombia because of high transport costs. ForestFirst has not yet harvested its first tree and consequently this system is untested.

To reduce risk one strategy might be produce acacia and eucalyptus on the same farm with cashew, cacay, rubber or cattle. Unfortunately, because labor use pattern of the ForestFirst production system does not create synergies with the other activities in the Vichada model. Labor requirements for the Forest First system are relatively low in the August to December period, but it is difficult to find an activity that could profitably use that time. The ForestFirst system has relatively high labor requirements in January and February when labor requirements are high for cashew and cacay harvest. Because of the need to monitor plantations for fire during the dry season, it would be difficult to reduce the forestry labor in January and February.

***Irrigated Oil Palm*** – Rainfed oil palm has been part of the Vichada analysis, but it does not enter into the solutions. When 50 hectares of irrigated land is available, and irrigated oil palm is introduced into the base UAF sized farm model with limited labor availability, the base solutions described above is repeated. Land is mainly allocated to cashew, with small areas of cacay and rubber.

In the high labor availability scenario (100 permanent workers, 1000 temporary workers per month), with the 50 hectares of irrigated land is available, all 50 hectares are planted to oil palm. The non-irrigated land is allocated to 606 hectares of cashew, 249 hectares of rubber and 52 hectares of cacay. All 100 permanent workers available are hired and temporary labor is a binding constraint in January and July. The estimated net return is 2,633,300,000 pesos which is enough to cover land ownership opportunity costs, pay family living and cover management. When wages of three times the minimum wage are needed to recruit workers, the irrigated palm stays in the solution, but the non-irrigated land is allocated more to relatively low labor cashew.

***Conclusions*** – The linear programming analysis of the Vichada agricultural opportunities suggests that cashew is a good option. It is a relatively high value product that can be profitable even with high

transport costs. Because cashew is shipped dry, it has the flexibility to wait until the Meta River is high and barges can make their way to Puerto Gaitan. Cashew requires relatively little labor.

In terms of farm crop and livestock choice the main question that is unanswered is “What the best activity to combine with cashew to effectively use family and permanent labor year around?” The cashew labor requirement varies from 0.16 days in April to 1.08 days in November and December. It is also relatively high in January and February. What crops or livestock would have their peak labor needs in the March to October period? Rubber and oil palm have relatively constant year around labor requirements and so do not create labor synergies with cashew. The two cow-calf activities in the Vichada analysis also have relatively constant labor needs from month to month. In the ForestFirst system their peak labor needs are January to July, which overlaps with the cashew peak labor months. It might be possible to design a forestry system for small and medium farmers that plans forest maintenance and harvest (if they do their own harvest) mainly in the March to October period. In terms of creating labor synergies one of the best options would be grain and oil seed crops planted in March or April and harvested in August, but with current transport cost cash grain and oilseed are unlikely to be profitable and feeding grain to hogs or poultry is also not promising because the local market is small and the cost of transport to the rest of Colombia is prohibitive. If ForestFirst succeeds in demonstrating that the barge route to Puerto Ordaz is viable the economic situation of Vichada would change dramatically. With Orinoco River transportation cashew, cacao, rubber and irrigated oil palm would still be profitable, but cash grain and oil seeds would potentially become relevant.

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