Who Gets the Human Appropriation of Net Primary Production?

Biomass Distribution & the 'Sugar Economy' in the Tana Delta, Kenya

Leah Temper

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The Land Deal Politics Initiative
www.iss.nl/ldpi
landpolitics@gmail.com

in collaboration with:
Institute for Development Studies (IDS)
University of Sussex
Library Road
Brighton, BN1 9RE
United Kingdom
Tel: +44 1273 606261 Fax: +44 1273 621202 E-mail: ids@ids.ac.uk Website: www.ids.ac.uk

Initiatives in Critical Agrarian Studies (ICAS)
International Institute of Social Studies (ISS)
P.O. Box 29776
2502 LT The Hague
The Netherlands
Tel: +31 70 426 0664 Fax: +31 70 426 0799 E-mail: iss.icas@gmail.com *Website: www.iss.nl/icas*

The Institute for Poverty, Land and Agrarian Studies (PLAAS)
School of Government, Faculty of Economic and Management Sciences
University of the Western Cape, Private Bag X17
Bellville 7535, Cape Town
South Africa
Tel: +27 21 959 3733 Fax: +27 21 959 3732 E-mail: plaas@uwc.ac.za Website: www.plaas.org.za

The Polson Institute for Global Development
Department of Development Sociology
Cornell University
133 Warren Hall
Ithaca NY 14853
United States of America
Tel: +1 607 255-3163 Fax: +1 607 254-2896 E-mail: ta12@cornell.edu Website: polson.cals.cornell.edu

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Abstract

In this article we focus on the connection between purchases of land and the emerging 'biomass-economy', analysing biomass distribution in a region targeted for land-grabbing in order to understand the process from both bio-physical and political ecological perspectives. We narrow the focus down to a case study in the Tana Delta, Kenya, one of the new commodity frontiers in the recent large-scale land acquisitions, employing an indicator derived from social metabolism analysis — the Human Appropriation of Net Primary Production (HANPP). This allows us to examine biomass flows in the Delta, combining a biophysical perspective with a political-ecology analysis of the interests, stakes and power politics in the delta. The first section introduces the conceptual tools and theoretical framework, expanding on the concept of the 'sugar economy' as a socio-metabolic transition, and material and energy flow analysis (MEFA) as valuable instruments in gauging sustainability and potential sites of conflict over biomass. The second section contextualises the case study of the Tana Delta in Kenya as a site of conflict over biological resources through an analysis of property rights and historical dynamics. The third section presents the results of the analysis of biomass distribution. The fourth and fifth sections offer discussion of the results and the conclusions.

About the author

Leah Temper is a researcher in Environmental History and Ecological Economics at the UAB and a freelance environmental journalist and video artist. Her area of study is Ecological Conflicts and Social Metabolism and she has done fieldwork in Israel, Kenya, Ecuador and India, studying conflicts related to land use, mining and energy. She has a bachelor´s degree in Communications Science and Journalism from Concordia University, Montreal. She teaches Economic History at the UAB and is one of the coordinators of the EU-funded CEECEC project, which focuses on Ecological Economics by and for Civil Society Organisations.

Acronyms

ABG	Aboveground Biomass
COMESA	The Common Market for Eastern and Southern Africa
DAP	Diammonium Phosphate
EIA	Environment Impact Assessment
EROEI	Energy Return on Energy Input
ETC	Environment Tourism /communities (ETC-Africa)
FAO	Food and Agriculture Organisation
GBP	British Pound Sterling
GDP	Gross Domestic Product
GEF	Global Environment Facility
GJ	Gigajoule
GPS	Global Positioning Satellite
GRAIN	Genetic Resources Action International
HANPP	Human Apropriation of Net Primary Production
IMF	International Monetary Fund
JBIC	Japan bank for International Cooperation
KISCOL	Kwale International Sugar Company Limited
KSh	Kenyan Shilling
KWS	Kenyan Wildlife Service
MEFA	Material and Energy Flow Analysis
MFA	Material Flow Accounts
NPP	Net Primary Production
TARDA	Tana and Athi rivers Development Authority
TDD	Tana Delta District
TDIP	Tana Delta Irrigation Project
TDM	Tonnes Dry Matter
TSIP	Tana Integrated Sugar Project
TRPR	Tana River Primate Reserve

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1. Introduction

Growing acquisition of farmland is being driven by several broad processes (GRAIN 2008; World Bank 2010; Zoomers 2010), including: the food crisis of 2008; rising meat consumption in Asia; biofuel targets; demand for wood and paper; and new long-term investment opportunities as a response to low interest rates, among others. In this paper, however, we focus on the connection between land purchases and the emerging 'biomass-economy', analysing biomass distribution in a region targeted for land-grabbing in order to understand the process from both bio-physical and political ecological perspectives.

The bio-economy or 'sugar-economy' refers to the vision of significantly increasing biomass as a feedstock for exosomatic[1] energy and industrial products. This includes increased agro-fuel production, as well as projected use of agricultural 'wastes and residues'. It also hinges on hopes of bio-technological advances in second-generation bio-fuels. The bio-economy can also be viewed more broadly — as the push to commoditise the biomass resources that are currently not yet in the market and to increase the biomass that comes to the market. Yet while The Economist (2009) glibly asserts that 'there is plenty of biomass to go around', this paper uses a conceptual framework of 'social metabolism' and 'colonisation of natural systems' to describe society–nature interactions (Fischer-Kowalksi & Haberl 2012), to interrogate current biomass use and distribution at different scales and among actors, examining:

- Is there enough biomass to go around?
- What are the current uses and distribution of biomass resources at global and local levels?
- What new conflicts are we seeing over plant matter, both crops and 'waste residues'?
- In a future bio-economy, more biomass, for whom?
- How much biomass will be left behind in nature available to preserve biodiversity?

We narrow the focus down to a case study in the Tana Delta, Kenya, one of the new commodity frontiers (Moore 2000) in the recent large-scale land acquisitions, employing an indicator derived from social metabolism analysis — the Human Appropriation of Net Primary Production (HANPP) (Vitousek *et al* 1986; Haberl 1997; Haberl *et al* 2009) This allows us to examine biomass flows in the Delta, combining a biophysical perspective with a political-ecology analysis of the interests, stakes and power politics in the delta, to answer Bernstein's (2007) four fundamental questions of agrarian political economy: Who owns what?; Who does what?; Who gets what?; and What do they do with the agrarian surplus?

The Tana Delta, on the east coast of Kenya near Somalia, comprises riverine forests, wetlands and rangelands and is home to a range of indigenous pastoralist, farmer and fisher communities, whose traditional multi-user livelihood strategies have helped preserve exceptional local biodiversity. Currently, there are eight planned development projects in the delta — six of them related to plantation crops, primarily fuel crops such as jatropha, oil seeds and sugar cane, as well as titanium mining and gas and oil exploration. Sugarcane represents the largest area, with the Kenyan coast being dubbed a new 'sugarcane belt'. Planned sugar projects include the TARDA project (20 000ha), MAT International (110 000ha) and another from Kwale International Sugar Company Limited (Kiscol) (8 000ha).

Looking at old and new agrarian conflicts in the Tana Delta, we ask:

- What can the history of the delta tell us about future potential for conflict and differentiated impacts on the people and local environment?
- What will the impacts of new land deals be on local food availability?
- What alliances are being made to protect the biodiversity and keep livelihoods intact?

The first section introduces the conceptual tools and theoretical framework, expanding on the concept of the 'sugar economy' as a socio-metabolic transition (Haberl 1997; Sieferle 2001) and material and energy flow analysis (MEFA) as valuable instruments in gauging sustainability and potential sites of conflict over biomass. The second section contextualises the case study of the Tana Delta in Kenya as a site of conflict over biological resources through an analysis of property rights and historical dynamics. The third section presents the results of the analysis of biomass distribution. The fourth and fifth sections offer discussion of the results and the conclusions.

[1] In human thermodynamics exosomatic energy, as contrasted with endosomatic energy (bodily metabolism), is the useful energy throughput outside human bodies.

2. The biomass economy and HANPP

Bio-economy describes the idea of an industrial order that relies on biological materials, processes and services, etc — a post-petroleum era in which industrial production is fuelled by sugars extracted from biological feedstocks. The switch to agrofuels is one important element in this new vision, but investment and corporate interest are also focusing on the enabling technologies of switching to synthetic biology's and nano-technologies that will allow the development of second-generation biofuels from lignocellulosic materials such as wood. For example, according to an 'Implementing Agreement on Bioenergy' policy paper (2004):

> *Although grain, sugar, and oil crops will continue to be important biomass resources, the use of lignocellulosic biomass is essential in the longer term. Lignocellulosic… feedstocks such as woody biomass, corn stover (dried leaves and stems), or other energy crops…will substantially expand the supply of biomass available for conversion and will help reduce the potential for food/fuel conflicts.*

The spectre of the biomass economy is integral to the current rise in farmland grabs: 86 % of global biomass is located in the tropics and subtropics (ETC 2010). Moreover, as the World Bank paper points out, these same countries have the highest 'yield gaps' of productive capacity not yet utilised (WB 2010).

Whether these 'cellulose dreams' (the techno-fix) will come to fruition remains to be seen, but the spectre of the biomass regime foreshadows an important, socio-metabolic shift of human relationships with the earth. The study of socio-metabolic transitions shows how land and energy use and resource extraction and consumption transform over time, fundamentally reorganising the relationship with the natural environment. Haberl *et al* (2010) discern three fundamentally different socio-metabolic regimes: hunter-gatherers; the 'controlled solar energy system' (Sieferle 2001) of agrarian societies; and industrial society, dependent on fossil fuels. The biomass economy is based on the idea of an impossible return to a metabolic regime based on solar energy flow after we have consumed a good chunk of the fossil fuels in the 'subterranean forest' that will provide humankind with an industrial standard of living.

Secondly, the bio-economy can be viewed not only as a techno-fix but also as a new 'spatial fix' (Harvey 1982) to a series of intersecting capitalist crises of accumulation we are currently facing — a fiscal crisis of the state, a lack of food and energy security, and climate change. The bio-economy is being posited as the long-awaited revolution in the new creation of 'ecological surplus' (Moore 2009) on the horizon. At the same time as it is seen as the way to transcend ecological limits, the whole rhetoric of the bio-economy is doused in 'green' imagery and hubris — representing the transition from black carbon to green carbon — as Frow *et al* (2009) write: 'as potentially environmentally sustainable commodities, the enthusiasm for plant derived products… tantalisingly might offer a way out of the zero-sum game between economic growth and environmental protection.'

However, the attempt to commodify new frontiers and the enclosures this entails will be met by counter-movements opposing the expansion of the market (Polanyi 1944). Thus the trend we are seeing and will continue to see is more conflicts over these sites of biomass production (GRAIN 2008). Compared to an average annual expansion of global agricultural land of less than 4 million ha, 45 million ha worth of large-scale farmland deals were announced even before the end of 2009 (WB 2010). While most of these are not yet under production and many perhaps never will be, the expansion of cultivated area is projected to increase rapidly. Apart from agro-fuels, population growth until 'peak population' has reached around 2050, the shift to meat-intensive diets, the increasing demand for paper pulp and for wood in general, are the driving forces of the present land grab.

To understand the aetiology of these looming conflicts, this paper uses a perspective combining political ecology and ecological economics. Political ecology can be defined as the study of conflicts over access to natural resources and services and over the burdens of impacts that arise because of inequalities in power, property and income among human groups (Martínez-Alier 2002). Political Ecology sees 'access to resources' as multi-faceted and contested and 'conflicts over resources' as being produced from broader processes of change within specific historical contexts (Blaikie & Brookfield 1987; Peluso & Watts 2001). Thus political ecology attempts to look past simplistic explanations for resource conflict based on scarcity (Homer-Dixon 1999) by clearly contextualising the object of study in a wider systemic understanding of economic power.

Ecological economics, build upon a thermodynamic foundation of economics, attempting to place the economy within the natural world and demonstrate the impact that economic throughput has on natural capital and biological processes. M'Gonigle's (1999) exhortation to unify political ecology and ecological economics points out that the:

'biocentric' perspective … seeks to discover principles that are more than purely human constructions as reference points of social accountability. In particular, the task is to situate human actions within the processes of the natural world, and to legitimise them to the degree that they can co-exist in balance with that world.

Following M'Gonigle, some authors have moved forward with synthesising political ecology and social metabolism analysis (Martinez-Alier *et al* 2010); i.e. conflicts over tree plantations have been covered by Gerber *et al* (2009) with, 'the objective to show that the metabolism of a given plantation can highlight the material causes of the resistance and that the latter is often expressed in non-monetary languages of valuation such as livelihood or sacredness'.

Social metabolism focuses on how social systems reproduce themselves biophysically (such as population, built infrastructure, artefacts and livestock) through a continuous energetic and material exchange with its natural environment (and other social systems). Social metabolism can be quantified in terms of energetic and material flows per time period, usually a year, and such flows can be expressed per capita or by unit area.

HANPP (Vitousek *et al* 1986; Haberl 1997; Haberl *et al* 2009) is one social metabolism indicator used by social ecologists to measure the human 'domination of the earth'. The inelegance of its acronym and its somewhat complicated (and contested) methodology have meant it has not yet achieved the wide usage accorded to its better known relation, the ecological footprint; however, the expansion of biomass harvesting and investment in future plans for exploitation signal the indicator's growing importance. The higher the HANPP, the less biomass is available in principle for species that constitute 'wild' biodiversity.

The HANPP indicator is calculated by seeing how much of the net primary production (NPP) biomass flows created through solar energy are appropriated by human activity, and how much is left in the ecosystems for other species. In this way, HANPP has been likened to a way to measure the 'scale' of human activities compared to natural processes — i.e. of the 'physical size of the economy relative to the containing ecosystem' (Daly 2006). As humans pass from hunter-gatherers to agriculture and then to industrial societies, they increase the degree of human presence on their surroundings. Later, HANPP decreases to some extent in some industrial economies, as fossil fuel reserves have replaced the need for fuel-wood and as imports of biomass (as feed-stuffs) increase in importance.

The sugar economy would see a reversal of this timid declining trend of HANPP. Further growth of biomass energy use would result not only in increased competition between food and energy supply, but also in further increases in HANPP with possible adverse ecological effects. 'Research can demonstrate that a transition from fossil fuels back to an area-related energy system (with agro-fuels) is not feasible at present population densities because of the low Energy Return on Energy Input (EROEI and the increase in the HANPP that it would imply' (Haberl *et al* 2011).

Global calculations, as well as some localised studies, have been undertaken for HANPP (Singh & Grubunhel 2003; Singh *et al* 2010). The novelty of this paper rests primarily in that we are concerned with the *distribution* of the human appropriation of primary production between two competing groups sharing the same territory and their distinct strategies for appropriating biomass through agriculture, grazing and other methods. So, we are not only concerned about the competition for biomass between humans and 'wild' biodiversity; we also want to show how there are distributive conflicts among humans about getting a share of the HANPP. This is less trivial than it may sound, as human activities do not only increase the HANPP, they may also increase the NPP (i.e. with fertilisers or by irrigation).

Like a large part of humanity, the inhabitants of the Tana Delta continue to rely almost entirely on local biomass production for their energy needs. In this way, their consumption can be seen as a type of 'GDP of the poor' (Sukdhev 2008). How does the ability to appropriate biomass outside the market relate to the well-being of the distinct groups? Finally, the study of HANPP and its distribution among the tribal groups also offers insight into the conflict between them, as pastoralists and agriculturalists.

HANPP is also a measure of sustainability and sustainable resource use in a spatially demarcated area. Since we are interested in the ecological resilience of the delta, it gives an indicator of the environmental pressure exerted upon the delta. Some studies have tried to establish the HANPP as an indicator of pressure on biodiversity (Haberl *et al* 2007b). We also build a scenario of what the new HANPP will be under the sugar scenario. We will thus have a model of the competing claims for the HANPP among different groups (human and animal) within the delta and their relationships to each other.

2.1 Methodology and data

Two field trips were undertaken to the delta in August of 2008 and in July of 2010. Structured and semi-structured interviews were carried out with government officers and workers, and environmental NGO workers based in Kenya, Malindi and in the delta, Tana and Athi Rivers Development Authority (TARDA) employees and villagers from Luo, Orma, Wardei and Pokomo communities. Surveys about biomass use, purchased products and household stocks were administered to eight Pokomo households, eight Orma households and one Wata household in July 2010. These results were then cross-referenced with literature to arrive at the biomass flow figures.

To understand resource conflict in the delta we analyse it as a process of accumulation through biomass appropriation, employing a methodology developed by the Institute of Social Ecology in Vienna (Schandl *et al* 2002; Singh *et al* 2010) to create a model of how the actors in the Tana Delta Irrigation Project (TDIP) area appropriate biomass. Local level biomass studies also give 'insights into the functioning of the subsistence economy normally underrepresented in national studies as well as insights into cultural coping strategies for dealing with land use change and industrialisation' (Schandl *et al* 2002).

2.2 The case study: The Tana Delta and TDIP

The Tana is Kenya's mightiest river. It flows over 1 000km from the foothills of Mt Kenya to empty into the Indian Ocean in Kenya's remote east. At its base lies the Tana Delta, one of the most important wetlands in 130 000ha, of which 69 000ha are regularly inundated (Hughes 1984, 1990). The range of habitats within it — including riverine forests, grasslands, savannahs, bush-land, lakes, mangroves, dunes, beaches and estuaries — mean it is a hotspot for biodiversity, supporting over 350 bird species, buffaloes, hyenas, hippopotami, the Nile crocodile and elephants. The Tana is also home to two endangered primates — the Tana River Red Colobus and the Crested Mangabey Monkey (Hamerlynck *et al* 2010). In the bio-economy, any land or water body that can sustain plants gains enhanced value as a potential site for biomass production. This is particularly true of areas that can be irrigated, as they can potentially produce significantly larger volumes of biomass.

> *The Tana River flood plain, with its high water table and frequent flooding, is by far the most productive habitat along the north Kenya coast (Andrews 1975) and it holds 50 % of the potential irrigable area in the country.*

There are two primary ethnic communities living in the delta: the Pokomo, Bantu-speaking Christian sedentary farmers; and the Orma, Kushitic speaking Islamic, primarily nomadic, pastoralists. The remaining inhabitants include the Wardei pastoralists, Luo fishermen and other tribes. The Pokomos practice flood recession agriculture along the low lying fertile flood plains adjacent to the banks of the river, which flood seasonally, and grow maize and bananas and other vegetables for subsistence and mangoes and rice as cash crops (Terer *et al* 2004).

The delta is an important dry season grazing areas for the pastoralists. The Environmental Impact Assessment (EIA) for the Tana Integrated Sugar Project (HVA International 2007) estimates that the delta hosts about 60 000 heads of cattle during the dry season, while 20 000 heads of cattle graze permanently in the area. In contrast, different NGOs give figures ranging from 200 000 to 350 000 cattle present in the delta during the dry season. Because livestock travel from as far away as Somalia and Ethiopia to the delta and the influx is highly dependent on climactic fluctuations, further research is needed to arrive at more precise estimations. In general, pastoralists in the delta maintain a higher standard of living than the agriculturalists. They oppose any project that could threaten their livestock and reduce grazing areas. The Pokomo, in contrast, are more sympathetic towards agricultural development projects but are wary due to unfulfilled promises in the past.

The environmental conservation group Nature Kenya, one of the main defenders of the delta, drafted a petition for the high court of Kenya, with members from both communities listed as petitioners. They highlight eight proposed projects noted as forming part of the 'scramble for the delta'. These include shrimp and prawn farming by Coastal Aquaculture Limited; the acquisition of 50 000ha for oil seed farming by British company, G4 Industries, (irrigated crambe, castor & sunflower); Bedford Biofuels jatropha plantations over an area of 90 000ha in local ranches adjacent to the delta; a proposed swap with the government of Qatar, allowing them 40 000ha (of which 16 200ha lie in the delta) of fruits and vegetables for export[2]; exploration for titanium by Tiomin Kenya Limited in the Kipini area from the sand dunes; and finally, the Tana Integrated Sugar Project, which was granted 40 000ha, up from the 28 000ha it owned previously, and MAT International, which is also interested in sugar-cane plantations (30 000ha of which would

[2] Both the Qatar project and the G4 industries project have since been shelved.

be in the delta and 90 000ha outside). If all these projects were to go ahead, at least 100 000ha of the delta would be turned into monoculture plantations.

This paper focuses primarily on the impacts of the Tana integrated sugar project (TISP), a joint venture between Mumias, one of the most important sugar producers in Kenya[5], and TARDA. The project was conceived to coincide with the expiry of Kenya's right to limit importation of duty free sugar from the Common Market for Eastern and Southern Africa (COMESA) region as of January 2012. Mumias hopes to produce in the delta the most inexpensive sugar in the continent at $160 a tonne, whereas currently the most efficiently produced sugar costs $200 a tonne (Mugambi 2009). The project would also produce ethanol for fuel and co-generation of electricity (HVA 2007). There are 18 villages with an estimated 25 000 people, split more or less evenly among pastoralists and farmers that stand to be impacted by the project. Gamba village, formerly inhabited by Wardei pastoralists who had been squatting there, has already been evicted (Schade 2011.)

3. The Tana Delta as commodity frontier

> *Tana River has also become an axis of regional contraband and illegal trade, especially in firearms, and cross-border movements of refugees, bandits and mercenaries.*
>
> Kagwanja 2003.

Co-existence in the delta between the communities is uneasy, sometimes leading to violence. The last flare-up of tribal conflict occurred in 2000–2001 between the Pokomo and the Wardei-Orma, but these tensions are not new, nor can they be convincingly explained merely by resource scarcity, overpopulation or the tragedy of the commons (Hardin 1968). Along this line, a recent Vision paper (2005) for the district states:

> *A key challenge in the management of land in this district is rampant conflict over access to and use of land between the farming sedentary communities and the pastoral mobile cattle keepers. As population pressure increases, resources that were traditionally set aside for either farming or pasture are increasingly being used or both causing long running conflict.*

A review of the historical relationship between the communities allows a more nuanced perspective on recent conflicts. The testimony of a visitor to the region in 1893 highlights that these tensions are not new or simply attributed to increasing resource scarcity; rather, they are based in power relations in the delta:

> *The Pokomo's however cultivate only sufficient to supply their own wants, as they have always existed in a state of insecurity and fear on account of the raids of their more powerful neighbours, the Swahili and the Somali. The Swahili … call all of the Pokomo as far as Ndera their slaves and take whatever they want from them by force … 7 The Gallas (Ormas) treat the unfortunate Pokomos similarly … The Pokomo … have no idea of offering any resistance to such high-handed freebooting, having been accustomed to it for generations. They look upon it as 'fate'.*
>
> New York Times 1893.

As in many places throughout Africa, property rights in the delta are often complex and overlapping, with concurrent systems of private, public, and common land and different rights to access, usufruct, leasehold and freehold. Much of the land in the delta is trust land, whereby the land is held in trust and administered by the county council for the 'benefit of the persons ordinarily resident of that land'. This trust land may be set aside for purposes deemed to benefit the residents, or transferred to the government (Okoth-Ogendo 1991). Yet there are many instances where this 'trust' is abused.

Apart from property rights over land, there are access rights to water. For example, among the Orma, wells are owned by the person who first dug the wells, and then their patrilineal descendants (Ensminger & Rutten 1991). While the Pokomo lay claim to the land along the river banks to practice agriculture, the Orma stake their claim over the river waters and oxbow lakes. Some theorists (influenced by Coase 1960) hold that clearly defined property rights should reduce conflict by creating shared expectations and through the creation of markets for damages. However, in practice, property rights are not easy to 'clearly define'. Regarding property rights to water, 'when a fixed expectation comes up against a fluctuating resource, that in itself can be a source of conflict' (Meinzen-Dick & Nkonya 2005) This is why rights of access to water are often ambiguous and based on principles open to negotiation rather than clearly defined rules; attempts to formalise rights that were previous customary thus can be a source of conflict in itself (*ibid).*

Thus one of the triggers for the flare-up of inter-tribal violence in the Delta in 2000–2001 was the actions of the land adjudication commission, began in 2000, which favoured a liberal land policy based on individual ownership. This policy created a sharp split between the Pokomo and the Orma/Wardei. The Orma/Wardei accused the government of fuelling ethnic conflict by imposing a neo-liberal land tenure system on an area, where land is communally owned, without adequate consultation.

> *This communal system provided two sets of rights: On the one hand was the right of ownership that the Pokomo were entitled to, as the 'indigenous' people to the area by the virtue of having been there before the arrival of the Orma. On the other hand, there was the right of access which the Orma were entitled to, and which the Pokomo guaranteed and defended. Traditionally, the Pokomo and Orma observed specific customary rituals and practices that allowed the Orma herders to gain access to water-points and pasture on the banks of the Tana River, especially during dry season. After elders from the two communities performed these rituals the latter set of rights became accessible to the Orma. These customary practices defining these rights emerged over the years, revealing a long interactive and integrative history of the two communities.*
>
> Kagwanja 2003.

In the Kenyan case, writers such as Okoth-Ogendo (1986) have argued that positive impacts of tenure reform have been completely offset by the emergence of economic disparities, redistribution of political power, and the dis-equilibration of socio-cultural institutions that have occurred in rural society as a consequence.

The year 2001 was also a dry one, adding fuel to the fire. Thus, while politically Tana has for long been considered frontier land, it is also in many ways an ecological frontier where the inhabitants and wildlife of the delta have adapted their lives to the extremes of drought and flood. Until now, such variability has made the implantation of capitalist agricultural development difficult.

The long rainy season floods fail on average in 2–3 years out of 10, and the short rainy season floods fail once in every 2 years. The erratic rainfall (500–800mm per year) makes agriculture a risky enterprise in the Lower Tana, in the sense that sole dependence on agriculture can be tricky and thus locals have adopted a variety of livelihood strategies they can fall back on in drier years when yields are lower. That said, in many years there exists high food insecurity and food aid is regularly dispensed (Eijk 1998).

The floods and the droughts that assail the region are also a product of anthropogenic change wrought by deforestation and dams upstream: humans have influenced the severity of both these events within the Tana Catchment (Ongweni *et al* 1993). Bearing in mind the highly variable climate in the region, the current project proposals for the delta seem to suffer from an 'optimism bias' — overlooking costs and overestimating benefits. Eijk (1998), studying the Hola scheme further upriver, noted how 'the unrealistic, over-optimistic planning of local and expatriate agencies with regard to irrigation development in the Lower Tana area … favours foreign consultancy firms and their local counterparts.' Eijk further asserts that development planning in Africa is mainly part of the art of government, in which planning goals are used as 'carrots rather than as realistic predictions'.

3.1 Past projects

The Tana River region is testament to a long history of failed projects to 'develop' the area, with investment from the World Bank (WB) and the government yielding few benefits for locals. The Kiambere Dam, completed in 1993, provided 140 megawatts of electrical power to Kenya's growing urban population. However, over 6 000 persons were displaced without any compensation, with those families losing over 82 % of their money-equivalent income (Kagwanja 2003). While the waters of the Tana River were supplying the country with electricity from before independence, most communities of Tana are still without. The Tana River Primate Reserve (TRPR) was another IMF/WB funded project that caused heated resistance. Based on the 'fortress conservation' logic of the incompatibility of human and animal co-existence (Neumann 1998), the local Pokomo were displaced from their ancestral territory to make way for a reserve for the Mangabey and Colobus monkeys. As the *Lonely Planet* guidebook shares in a quirky aside, things came to a head when 300 naked Pokomo women stormed the research centre in protest. Recently, the World Bank was ordered to pay KSh634 million (£4.8 million) compensation to the displaced after the high court in Mombasa found that the World Bank and the Global Environmental Facility (GEF) failed to meet its promises to provide 15 acres per household, a house, compensation for lost trees and crops and KSh50 000 (£380) per family. Plans to build houses, schools, mosques and churches also never materialised (Daily Nation 2010).

The TRPR logic is based on the conception of Africa as a zoo or thematic park for foreigners and scientists, a common complaint in a country where seven % of the land — an area the size of Denmark, is designated as National Parks and protected by armed guards from the Kenya Wildlife Service (KWS) to create, in the words of Peluso (1993), 'a mythical nature devoid of humans for tourist consumption.' The next project was the Bura Irrigation Scheme, implemented in 1978, with the original aim of settling around 5 000 farmers in 23 villages to grow cotton and maize on 6 700ha of land. An additional 4 500ha of irrigated forestry were to provide for the fuel-wood of the estimated 60 000 settlers. The Bura scheme was crippled by corruption and mismanagement. The wrong choice of pumps was made whereby components and spare parts came from different continents. Siltation destroyed the pumps and the dredgers were rendered useless (JBIC 2001). In a country with per capita income of about US$350 (£220) per year at the time, the project spent an incredible US$35 000 (£22 000) for every settler (Horta 1994). Yet today, the settlers are poorer than before and the area is a wasteland, overrun by the invader bush Mathenge.

3.2 The TDIP and the Mumias Project

The most recent 'white elephant' project was the TDIP rice scheme, managed by the TARDA. The TDIP represented a switch in policy from irrigation schemes with settlement and freeholders to new plans for 'economically motivated' commercial estates with a few out-growers.

These new estate schemes, while unlikely to have the same impact on unemployment and landlessness as settlement, were thought to be more likely to produce an economic return. Yet only a few months after starting full operations, the TDIP rice scheme collapsed due to flooding after the El Niño rains in 1997 (Luke *et al* 2005).

The TDIP scheme removed 2 500 acres (1 042ha) of either utilised or available cultivable floodplain land lying within Pokomo-demarcated lands as part of the project's total of 10 000 acres and also converted former grazing lands. The affected communities list a number of unfulfilled promises by TARDA, including not paying for crops in a timely fashion and not building promised schools and hospitals. Moreover, after the construction of the embankment, TARDA claimed the land as their property. The communities are still in court trying to reclaim the land that was expropriated from them; despite the fact that the case is still pending, the new Mumias sugar project is planned on the same disputed area. The Mumias Project involves recuperating the rice scheme, and growing sugar in an estate over 16 000ha and another 4 000ha for out-growers, as well as a livestock component. Mumias has plans to install an 8 000 tons-per-day sugar mill and distil 23 million litres of agro-fuel ethanol per year from molasses, a cane by-product. It would also produce 34 megawatts of electricity per day from bagasse. Because numerous studies have been undertaken in the TDIP area, we use the area delineated by the original TDIP project (covering some 5 000ha) as the system boundaries of our biomass calculations.[10]

Six villages are commonly associated with this TDIP Polder 1 area, with land falling within the traditionally-demarcated boundaries of three of these — Kulesa, Wema and Hewani — incorporated into the project, whilst the other three villages — Bfumbwe, Sailoni and Baandi — border the project area, and have traditionally utilised 'common property' resources within the project area, and continue to do so — typically in the floodplain forests, and available grazing areas. In 1990 the population inside the TDIP was estimated at approximately 5 000 people, with a population growth rate of 13 % every five years (HVA International 2007). All the villages are inhabited by Pokomo cultivators, with the exception of Baandi, which is inhabited by traditional Orma pastoralists.

4. Results: The HANPP

This section presents the livelihood strategies and biomass appropriation of two traditional villages in the TDIP area — one agriculturalist and one traditionally pastoralist — that currently also practice farming. The data demonstrates the diverse and contrasting ways that the local communities appropriate biomass in the delta to sustain their livelihoods.

> *The ability to profit from biomass is based on political economic and natural factors. Relative prices of products, price elasticity for goods, market linkages, ecosystem functioning .... Arguments about productivity. Data shows that pastoralism, long considered an "underproductive" activity may be the most profitable and beneficial means of biomass apropriation in certain environmental contexts.*
>
> Krausmann *et al* 2008.

It also shows how success in harvesting biomass is linked to economic well-being. Apart from bringing differences between villages to light, the data also presents issues of productivity, incorporation in the market economy, food security and dependency. We use a methodology for HANPP derived from the Institute of Social Ecology but modified,

because we do not calculate potential production before human modification but only look at actual production and distribution. the amount of NPP co-opted by humans or the HANPP of harvest[3].

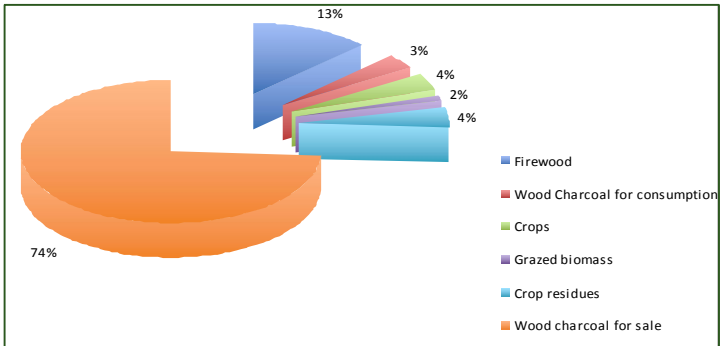
4.1 Biomass use among the Pokomo

Vumbwe is a Pokomo village, settled in the current location after the floods of 1961. It is a community of 20 Pokomo households (312 people) and seven Wata households (24 people). We surveyed eight Pokomo households and one Wata household about their farming practices, household consumption and time use. We cross-referenced this data against GPS measurements of land use and the literature. We then calculated average biomass use for a range of consumption activities per person in gigajoules (GJ) — illustrated in *figure 1*.

All the Pokomo families surveyed practised farming — with an average of 2.2–3 acres (1ha) per family, ranging from half an acre to 4 acres per household[4]. Two thirds had a small number of chickens and 45 % had beehives. Almost all families also practiced fishing, with fish being an important source of protein in certain seasons[5]. Two of these used fish traps, which they left in the oxbow lakes, and sold fish. In Vumbwe, other livelihood strategies were charcoal making (30 %), wage labour (30 %) and small businesses such as a local kiosk (30 %). No fertilisers were applied, but two families did use a small amount of pesticides on vegetable crops produced for sale only.

Two farmers in the village practiced irrigation (with a diesel powered pump) and the same two households own generators. Two other households have solar panels. The remainder of the village relies entirely on firewood (an average of 6 tons per HH/yr)[6] and charcoal for heating and cooking and paraffin for lighting[7]. A third owns a bicycle and half of the households have a radio.

Figure 1: Vumbwe biomass use per capita



The primary crops planted by all surveyed included maize, usually planted over half the field area, and often intercropped with cowpeas, with another half-acre cowpeas and green-grams; some grow vegetables such as Skuma (kale), tomatoes, onions, and bananas as cash crops. Average maize yields for 2009 were 1.5 tons of maize per ha (almost seven 90kg bags per acre). This was considerably higher than most reports of local yields, for example the EIA mentions yields of only 2–3 bags per acre compared to up to 15 bags in other parts of the country. Eijk (1998) found a similar phenomenon of understating yields in his field research:

> *Project staff had erroneously assumed that the yields in flood-fed fields were considerably lower than in irrigation schemes. Only when in 1984 the agronomy unit of LTVIP started to take samples in the farmers' flood-fed fields, it became clear that the yield levels of these plots had been grossly underestimated. In their eagerness to promote irrigation schemes Kenyan and Dutch staff members alike had painted a bleak picture of*

[3] HANPP can be expressed in absolute numbers as kilograms carbon per year (kg C/yr), as kilograms dry matter biomass per year (kg DM/yr) or as energy flow (Joules per year, J/yr). As a rough proxy one may assume that 1 t DM is equivalent to 0.5 t C and that the calorific value of dry matter biomass is around 18.5 Megajoules per kilogram (MJ/kg, 1 MJ=106 J).1 kg dry matter biomass = 0.5 kg C = 18.5 MJ.

[4] The average for the Tana Delta district is 2 acres (Tana River District Development Plan (2002–2008).

[5] While we collected data on fishcatch and fish purchases in the diet, we did not include this form of biomass because we did not measure the NPP of the lakes.

[6] Hughes (1984) estimated that the average family in the Bura Scheme uses 6.14m3 solid volume of wood per annum. (Development schemes on the River Tana.)

[7] This is indicative of the district as a whole whereby 98.8 % of the households rely on charcoal or firewood.

the local farming system. Although total or partial crop failure definitely occurs once in a while, the farmers harvest a good crop in seasons with adequate depth and timing of flooding.

Most families also have mango trees from which they sell mangoes, but most mangoes rot on the trees due to lack of marketing outlets. Women and young children in most families practice gathering of greens such as water lilies and other wild plants. Two women interviewed described themselves as midwives and also collected a range of medicinal forest products. According to Medley (1993), the Pokomo use 98 plant species locally, accounting for 52% of known species in the area; Vumbwe village uses forest 65 (46ha) and forest 68 (43ha) and also the Gubani woodlands. The Crops they grow provided 2GJ of energy per year per person, approximately two thirds of energy needs, with the remainder perhaps coming from fish, small amounts of meat, and purchased products (rice, sugar, wheat flour & oil).

The primary extraction of biomass among the village was due to the production of charcoal, accounting for 75 % of extraction (*Figure 1*). Several sources confirmed that about half of the households in Vumbwe produce charcoal for sale with an average of 40–60 (50 kg)[12] bags per week being produced by the village. This equals approximately 20 tons of wood extracted for charcoal consumption per week. Charcoal is harvested in the delta primarily from along the floodplains where the tree growth is lushest. The Pokomo engage in this trade more so than the Orma, particularly in certain seasons when the opportunity cost of labour is low (Ensminger 1984).

In Vumbwe village, there are 26 members of the Wata tribe who belong to one family, with 8 households between them. The Wata are the smallest and one of the most marginalised tribes in Kenya. They are traditionally hunter-gatherers. Parker and Amin (1983) believe that the Wata were the most likely source of much of East African ivory dating back 1 200 years. We interviewed one male household head of 49 years, he was the only one interviewed who engaged in every livelihood activity on the survey including: farming, livestock-keeping (goats), beekeeping, fishing, gathering, business, hunting, charcoal-making and wage labour (at Tarda). He can produce up to 20 bags of charcoal per week when he has an order. If there is no order he produces at least 5 bags. He estimated 30 minutes of work per 50kg bag. Each bag sells for KSh175, as an average between wholesale and market prices. Thus he can make KSh87 500 (£665) annually for a declared 250 hours of labour — a return of KSh350 (£2.66) per hour.

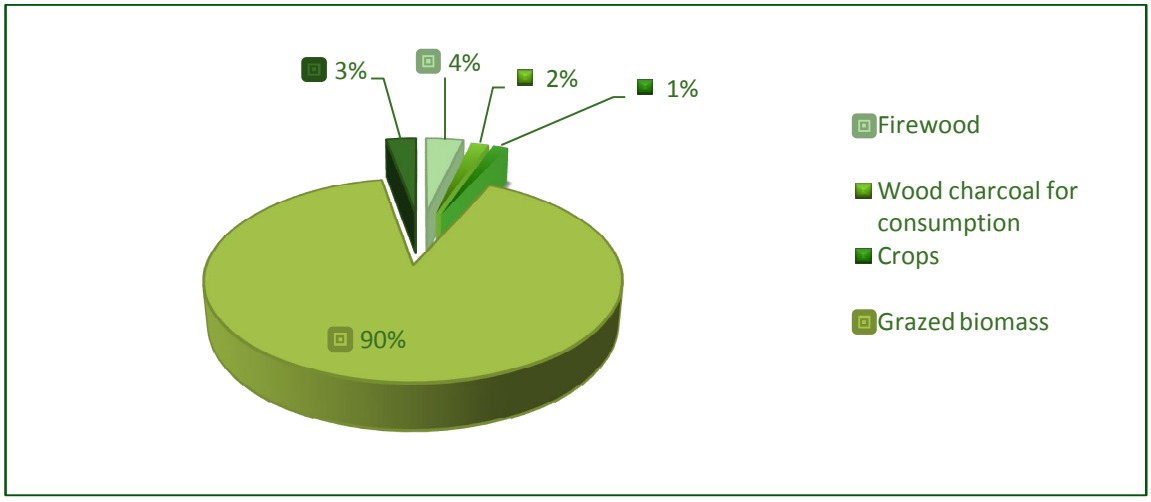
According to the respondent, despite it being illegal, they continue to hunt large animals, hunting 4–5 small animals and one large mammal such as a hippo, giraffe or buffalo per year. The meat is shared out among the hunters, with the surplus dried and sold in the village and surrounding areas.

4.2 Biomass use among the Orma

Baandi village is a community of 204 houses, comprising 1 000 people. The village has existed on a permanent basis in close proximity to Hewani village since 1988, after the villagers were forced to leave their previous permanent village, Gardeni — a few hundred metres further south — due to flooding. The Orma residents of Baandi distinguish themselves amongst pastoralists as being 'permanent' within the Tana River delta.

Bandi makes use of forest 64, and two others outside the project area, one to the north and one to the east of the village. We calculated a median of fifteen heads of cattle per household (an average of 72) although other studies mention that more nomadic Orma villages have an average of 100 per household (Luke 2008). Households also have significant stocks of sheep and goats. However, because of the wide variation in holdings (represented by the large difference between median and average), it is difficult to estimate livestock numbers with certainty. According to several people interviewed and local district livestock officers, only 50%–60 % of Orma own cattle, of the local Boran breed. One household we interviewed had 500 head of cattle while another had none. The Orma pastoralists of Baandi move out of the sodden Tana delta during the long rains (March–April), utilising outlying grazing areas until stocks are diminished and returning to the delta as the long dry-season progresses (August–September). They then remain in the delta until the following year's long rains return. Access to grazing on and around the wetter floodplains of the current TDIP, through both the long and short dry-season, is a critical component of their livelihood survival.

Figure 2: Baandi Biomass use per capita



Mean weight for a cow is 200kg–250kg. Milk provides about half a litre per person daily (20% of caloric needs) and the excess is shared or sold. The Tana Delta District (TDD) exports only 3 500kg of meat and 2 500l of milk monthly according to the district Livestock Officer. About 1 000 head of cattle and 1 000 shoats (sheep and goats) are exported each month. The Orma rarely slaughter their cattle; milk is the main product from cattle consumed locally. About 4.7 million litres of milk were produced in 2000, with production peaking during the wet season (Irungu 2000). Reported yields for maize were in fact higher for Baandi than for Vumbwe, yielding 32GJ per ha as opposed to 21GJ/h. One possible explanation for this is that while none of the respondents in Baandi reported using fertilisers or manure, they did report that they graze their cattle in the fields after harvest to remove plant residues and they then leave the manure behind. Despite this, crops account for only 2% of the extraction of biomass by the Bandi village (*Figure 2*).

Ninety % of biomass extraction was grazed biomass to sustain cattle and shoats, accounting for 9 tons pp. Fuel-wood use is half as much in Baandi (440kg/pp/yr) than Vumbwe (860kg/pp/yr). This is because their diet is much more dependent on milk for calories and protein. However, the Orma also use wood for their houses, with an average size house comprising 1 100 (twenty-five kg) poles (Ensminger 1984), and for fences for cattle *kraals* (enclosures for cattle). Agricultural residues represent 3 % of biomass extraction, mostly consumed by cattle. Two % (GJ) was also attributed to charcoal consumption. The process of nomadic pastoralists settling leads to dietary changes and consequent changes in biomass use. As Ensminger (1984) writes:

> *… the area around permanent settlements is fairly quickly overgrazed, livestock produce less milk … formerly the dietary mainstay. These lower production yields necessitate that sedentary households be drawn into the market economy in order to purchase supplemental foodstuffs. It is for these reasons that the processes of sedentarization and involvement in the market economy are so closely linked. This change in diet, from milk to cooked grains and tea, accounts for a great deal of the increased fuel use by sedentary households.*

A further shift of pastoralists from livestock keeping to farming will lead to increased pressure on forest resources unless alternate fuels are promoted. Another important flow of sustenance, for the local Orma, is food aid, which in 2009 was distributed to 25 % of the population of the Garsen district. The Orma receive more food aid than the Pokomo. According to the Red Cross, they distributed over 143 223MT of cereals, as well as pulses, oils and blends. The allowance equals 2.5GJ/pp/yr, which represents almost 70 % of an average annual caloric intake of 3.5GJ/pp.

4.3 TARDA

In 2009, TARDA also rehabilitated a part of its project destroyed by the el Niño floods with a KSh400 million economic stimulus program from the government. They planted 550 acres of land to maize under a rain-fed system, with the intent to make the transition into rice cultivation. The yield was extremely low, at only 5.6 bags (90kg) per acre (14.4 bags per 18.5GJ/ha). The Tarda production manager attributed this to low rainfall and the wrong seed being delivered in the current season; yields were triple the previous season. diammonium phosphate (DAP) Fertiliser was applied at 100kg/ha, as well as pesticides. About 400–500 employees were employed monthly, primarily as ‘scarers’ (dissuading

wild animals from eating their crops) during the harvest season, at a rate of KSh250 for an 8 hour day (£1.9)[8]. While the yields were from 2.5 to 4 times the magnitude those achieved by the Pokomo and Orma farmers respectively, the maize grown by TARDA never made it to market. The maize was meant to be delivered to the National Cereals Board but was improperly dried in storage and developed Aflatoxins and had to be discarded. An audit carried out in 2010 regarding the Emergency Food Program points to a long list of mismanagement issues on the part of TARDA such as overpaying for basic machinery. Yields were considerably lower than expected and point to the mismatch between projected productivity and actual productivity in large-scale operations.

4.4 Sugar scenario

To compare biomass distribution among users in the delta, in the current scenario and in the sugar scenario in the TDIP area, we have contrasted the biomass per capita data based on the population in the TDIP area with local HANPP data from global series (available in a 10x10 scale) — elaborated by Haberl *et al* (2007a) — to come up with a schema of current biomass use. Finally, as a conceptual exercise, we have created a scenario of what the land use, biomass production and HANPP will look like if the Mumias sugar project is to go forward (this data is summed up in *Figure 3*). The global data was cross-checked with other local biomass productivity studies (Glenday 2005) and with survey data from interviews and regional data from local officials. In the scenario, we consider that the land allotted to TARDA within the TDIP area (4046ha), minus the land that is currently built-up (124ha) or forest and woodland (1241ha), is cleared and turned over to sugarcane. Whereas, currently the Pokomo cultivate 660ha and the Orma 90ha in the TDIP[9], with over 3 058ha being available for grazing or other land uses, in the scenario, after land use changes, only 382ha of non-forestland will be available for both communities and wildlife.

Regarding the production and appropriation of biomass in the sugar scenario, assuming the projected yields of 150 tons of cane per ha are achieved, this translates to 69TDM/ha/yr. This leads to increased biomass production, from 154 000TDM to 358 000TDM — an increase in NPP of aboveground biomass (ABG) production of 2.3 times over previous levels, due to inputs, including fertilisers and irrigation. The current HANPP shows that currently only 26% of biomass is being appropriated. In the sugar scenario, while biomass production increases, over 80% of this is appropriated by TARDA alone, with less than 20% of available biomass remaining for the two communities, other species and left behind as forestland.

Figure 3: Current and potential biomass production ('000 TDM), land use and HANPP

	Land use (ha)		Biomass use per user (in '000 tonnes of dry matter)		HANPP (%)	
	Current	Sugar scenario	Current	Sugar Scenario	Current	Sugar scenario
Pokomo	606		18.4		7.7	
Orma	90		10,0		4.2	
Tarda	222	3594	2.5	258.8	1.1	72.2
Biomass for other species/ unaccounted for	3058		30.5		12.8	
NPPh	918		61.5	289.1	25.7	80.7
NPP remaining in Ecosystem	4299	382	114.5	69.2	74.3	19.3
Total NPPact/Total land area	5341	5341	238.9	358.316	100	100

Furthermore, this increased HANPP does not account for the increased pressure on forests. The EIA estimates that due to population growth alone[10], an additional demand of 1 million kg of fuel-wood per year will be needed across the entire project area (HVA 2007). This will be considerably more due to the projected influx of settlers. Furthermore, charcoal harvesting will probably increase as the Pokomo seek ways to complement seasonal labour from the plantations. Unless a forestry component is put into place, the result will inevitably be 'development induced

[8] The project manager did inform me however that their jobs would soon become obsolete as they would be installing an electric fence next year.

[9] Current land use accounts for the average pc cropland per Pokomo (0.13ha) times the current population in the TDIP (4665), while the Orma land use also accounts for cropland only (0.06ha pc for a population of 1500); the land use for TARDA accounts for land currently under rice production.

[10] Population growth in the Tana Delta District is 3.4% annually.

desertification spread as concentric rings around the schemes' (Johanssan 1991) and conflict between the traditional population and new migrant workers[11]. Calculating the new HANPP distribution between the Pokomo, Orma and other communities in the scenario would be mostly speculative, although it is likely that in fact most villagers would lose their land entirely and become day labourers, and that keeping even half of the livestock would become unfeasible.

Yet, while this scenario is illustrative, it should be kept in mind that the level of analysis covers a relatively small area of only 5 000ha; the analysis should calculate the actual and potential biomass distribution across the entire delta area. Given that the area is also being targeted for the establishment of extensive Jatropha biofuel farms by Bedford Biofuels (Canada, 50 000ha) and G4 Industries (UK, 28 000ha) that will reduce the grazing land on the terraces surrounding the delta and thus potentially further increase pastoralist pressure on the central wetlands. Still, should these new projects and rehabilitations become operational — even for restricted time periods until government subsidies or donor funds run out again — they will result in increased water off-take which may reduce the flows necessary to the survival of the riverine forests in the delta.

5. Analysis

This paper has employed an analysis of biomass production and distribution to approach the question of whether massive quantities of biomass can be harvested sustainably without eroding and degrading soils, destroying biodiversity, increasing food insecurity and disrupting the livelihoods of marginalised peoples. Some possible insights we will explore in this section include:

- the relative (un)sustainability of the current land uses and potential future land conversion and issues of distribution;
- benefits and complementarities of current multiple land use systems; and
- strategic alliances that may develop in opposition to and as a result of increased agricultural intensification.

The world's total NPP is 172 x 109TDM/year (Openshaw 2010); of this total, only a fraction is extracted — 20–40 %, depending on the methodology (Imhoff *et al*. 2004; Vitousek *et al*. 1986, Haberl *et al* 2007a) — and only 7 % of used biomass extraction is traded. From 1962 to 2000, global aggregate exports of biomass grew by a factor of 4.7, crops by a factor of 3.9, animal products by a factor of 2.8 and wood and forest products by a factor of 7.8 (FAO 2005). The rate of increase since 2000 has been even faster. This growing spatial disconnection between the site of production and consumption inevitably leads to a process whereby local land use and local human needs decrease in importance as determinants of land use decisions (Erb *et al* 2009).

However, if we want to use HANPP as an indicator of environmental space, similar to the ecological footprint in the context of biomass trade, one must also consider the upstream flows generated by imported products. This concept has been called embodied HANPP or e-HANPP. For example, Haberl *et al* (2010) estimate that one litre of biodiesel requires the appropriation of 7 tonnes of e-HANPP.

Once we consider embodied HANPP (e-Hanpp), international net transfers become more significant, amounting to 1.7 PgC/year or 12 % of global HANPP (Erb *et al* 2009). Most of this does not cross borders, but is due to upstream processes of traded commodities. Of this, 88% is supplied by low-density countries with an average population density of 14 inhabitants per km^2, including both industrialised and developing countries, while 75 % of the international net flow of embodied HANPP is consumed in high-density countries with an average population density of $161km^2$[18]. Currently, biomass flows are dominated by only a few participant countries, with many economies existing at subsistence level and not trading. The transfers are characterised by exports from sparsely populated regions and imports from dense countries. Interestingly, development status does not seem to play a role in this dynamic. For example, among the top HANPP importing countries, including Japan, South Korea, China, Saudi-Arabia and Egypt, we see both high and low-income countries that have been connected with land purchases; primary exporters are neo-European countries such as the United States, Australia, Canada and Argentina (Erb *et al* 2009).

[11] In August 2012, the long-running conflict between Orma and Pokomo has broken out once again with over one hundred people and hundreds of cattle massacred. The fighting has been attributed to conflict over grazing land but also political manipulations due to the increasing value of the Delta's resources and increasing demands by local (both private and state) and international investors for land in the Tana Delta (Gachanja 2012).

5.1 Sustainability and Distribution

The data presented has only hinted at some of the environmental problems such as land and forest degradation at the local scale that may be associated with increased flows of biomass.

While material flow analysis can give a perspective on the productivity and efficiency not encapsulated by purely monetary analyses, here is where some of the limitations of biophysical indicators begin to express themselves. Material flow account MFA data does not offer an integrated analysis of the local economy: economic, political and cultural elements cannot be expressed in TDM. Moreover, biophysical data is not a clear indication of the sustainability of extractive and agricultural flows. The relationship between more biomass and other measures of sustainability/livelihood impacts is not linear. Just as the correlation between species diversity and HANPP is difficult to gauge because HANPP may favour some species at the expense of others, contrasting uses of HANPP will favour some groups at the expense of others. For example, HANPP does not tell us the relative sustainability of local practices of livestock grazing and charcoal burning. While local reliance on traditional breeds is considered relatively unproductive and large herds are viewed as the result of the pastoralists' 'irrational' attachment to their animals rather than economic gain, this is not always the case. For example, a study of the Borana system in Ethiopia found it very productive compared with Australian commercial ranches — the Borana produced nearly four times as much protein and six times as much food energy per hectare. Their major concern was not the number of cows owned but the number of people supported by the rangeland (Cossins 1984).

Moreover, the effect of grazing grassland productivity and grazed ecosystems is generally not well understood. Studies show that grazing may simultaneously enhance — 'compensatory growth' — or reduce productivity — 'degradation' (Haberl *et al.* 2010). Flows demonstrating the proportion of annual primary production available to livestock and the proportion actually consumed, combined with tolerance levels of different plant communities to exploitation, are called for to understand the impacts of pastoral land uses.

Although commercial charcoal production on public lands has been illegal in Kenya since 1986 as an effort against deforestation, enforcing this ban is difficult in a country where 85 % of the population depends on charcoal, and in 2002 the government estimated that 2.4 million tonnes were consumed countrywide. Here different environmental narratives between the state and local users can be heard. According to local charcoal-makers, the trees they burn were cut by TARDA when they cleared land and being too big to be collected, would otherwise rot in situ. While decried as wasteful, the EROEI of charcoal seems favourable when compared to that of biofuels. While 60 % of the original energy is lost in the conversion process from wood to charcoal, the resulting fuel has: twice the energy of the parent material; is less polluting; is more convenient to use; and cheaper to transport. By contrast, for electrical generation from fossil fuel, up to 75 % of the energy may be lost in production and distribution.

Finally, HANPP data tells us nothing directly about water availability, the primary limiting resource in the delta. Further research should complement biomass accounts with virtual water export calculations, as the land grab is concurrently a water grab[12]. Despite the fact that in the current debates about the impact of foreign investment in agricultural land, the consideration of water has been peripheral. A recent review of land deal contracts by Cotula (2011) observes that land leases in semi-arid countries would be worthless if they did not ensure access to sufficient water, and while the report by the World Bank (2010) explicitly states that its estimates of farmland 'available' for investment are based on suitability for rain-fed production alone, it appears evident that investors will look for irrigable land. The specific ways in which water underpins land productivity in the semi-arid and sub-humid African savannahs needs to be better understood, particularly due to the impacts upon existing local water resource users.

5.2 Complementarities

The flow of energy and the cycle of nutrients in the delta demonstrate how the balance between different land uses is a crucial element of the maintenance of socio-environmental stability (Cusso *et al* 2006; Hamerlynck *et al* 2010) and how interactions between multiple uses of nature contribute to increased productivity. As a means of insuring against the constant threat of drought, famine, epidemics and stock-raids, the communities developed inter- and intra-communal and external links.

[12] Despite the fact that in the current debates about the impact of foreign investment in agricultural land, the consideration of water has been peripheral, a recent review of land deal contracts by Cotula (2011) observes that land leases in semi-arid countries would be worthless if they did not ensure access to sufficient water.

Pastoral land use practices (adoption of cultivation, abandonment of nomadism, permanent settlement, landscape fragmentation) affect the distribution, diversity and viability of nutrients, vegetation, biodiversity and landscapes in ecosystems. Backflows into the system, such as manure, create nutrient cycles that improve biodiversity. Farmers also benefit through increased soil fertility distributed during the annual flooding, which contributes to the high productivity of floodplain agriculture. In the delta, human–wildlife relationships are antagonistic at times and mutually beneficial at others. Farmers spend a significant amount of time in the field as 'scarers', preventing primarily baboons by day and buffaloes at night, from eating their crops. Wildlife also injure and kill many livestock (HVA 2007). Villagers are sometimes paid off for these damages by the KWS — a type of payment for environmental services. Meanwhile, the picturesque town of Moa has an oxbow lake that supports 300 (Luo) fishermen, largely due to nutrient flows from wildlife, such as:

> *hippos ... that have a significant effect on aquatic nutrient concentrations in that they feed on terrestrial vegetation at night and defecate in the water, which can figure some 1000kg/ha/year of dung … The transformation of plant material into mineral rich cow dung in its turn favours next year's aquatic plants and fish production.*
>
> Marchand 1987.

MEFA can track the cycles of residues and wastes that are not apparent in typical financial accounting. This includes nutrient cycling, such as the dung of hippos and crop wastes sown back into the soil. Such an analysis cautions that while the development of cellulosic technologies will permit using crop residues, removal of such 'waste' residues from the field must be balanced against impacting the environment (soil erosion), maintaining soil organic matter levels, and preserving or enhancing productivity (Wilhelm *et al* 2004).

Some papers have explored the relationship between NPP and biodiversity (Haberl *et al* 2007b). The species–energy hypothesis (Wright 1983) states that the number of species is positively related to the flow of energy in an ecosystem, although a direct correlation has not been firmly established. However a certain level of NPP can be considered a necessary, but not sufficient condition to maintain certain types of biodiversity. Then as the HANPP increases, biodiversity will decline, leading Vitousek *et al* (1986) to propose HANPP as an indicator of pressure on biodiversity. Yet the diversity of the biomass itself is of course equally important, particularly for species that are as picky in their diets as are the Red Colobus Monkeys, which eat only very select leaves. While the Colobus do not consume human food, they are an edge species, preferring forest edges over mature forests. Similarly, the semi-terrestrial Tana Mangabey are well adapted to a landscape mosaic with alternating fields, forests and bush (Hamerlynck 2010). According to a recent study, one of the biggest causes of human–wildlife conflict between primates and humans is the encroachment of the invasive species Mathenge (*Prosopis juliflora*), a shrub that has taken over large swathes of the delta since it was introduced as a fuel-wood crop under the Bura scheme (Johanssan 1991). It has now become a serious pest in the entire delta, causing significant damage to livestock as well.

5.3 Alliances and resistances

Pastoralists are particularly vulnerable to sugar cane and bio-fuel development and the possible growth of the bio-economy, because they occupy the marginal and 'waste' lands' targeted by crops such as Jatropha, and the irrigable dry season grazing areas favoured for sugarcane plantations — two crops that imply vastly different labour and social organisations and impacts. Governments are also seizing this opportunity to encourage more intensive cattle-raising with imported breeds, simultaneously achieving goals of settling grazing-dependent nomadic communities (Scott 1998) and increasing the state presence in frontier regions (Kajwanga 2003). As a result, in many places, pastoralism is under threat of losing significant land to other resource uses, perceived by governments to be more productive.

One of the lasting impacts of projects in the Tana Delta has been the creation of deep resentment in the local communities against development/conservation projects and their implementing agencies, such as TARDA and KWS (Hamerlynck *et al* 2010), with the TRPR case representative of the often opposing positions of conservationists and local communities in Africa. Historically, conservationist groups have been critical of overgrazing and overstocking of cattle by pastoralists. The antagonism between pastoral communities and environmentalists can also be attributed to the fact that in East Africa, wildlife conservation has robbed pastoralists of a significant part of their traditional range. This is because pastoralist survival strategies create ecosystems well suited to grazer ecology and because herders didn't subdivide the savannahs (Homewood & Rogers 1991). As a result, pastoralists are now surviving on a small fraction of their traditional grazing areas, and are highly critical of attempts by conservation interests to claim the remaining pastures for wildlife preservation (Cooke 2007).

In the current situation we are beginning to see strategic alliances arising. In the fight against the sugar company, environmentalists and pastoralists have entered into a temporary marriage of convenience. Here we see the combination of two streams of environmentalism aligning to mutual benefit: the cult of wilderness with the environmentalism of the poor (Guha & Martinez-Alier 1997).

Nature Kenya is the Kenyan branch of the East African Natural History Society and the oldest conservation organisation in Africa; their conservation programme aims to promote sound management and sustainable utilisation of natural resources at important biodiversity sites. Its activities in defence of the delta so far include submitting statements and comments to various environmental impact assessment reports and surveys; commissioning a cost-benefit study that focuses on the environmental values of the delta; the production of an advocacy film, *Is Tana Sugar Really Sweet?*; and advocating for a conservation and development master plan developed by the government in consultation with local people and all interested parties to safeguard local livelihoods and wildlife, while permitting sustainable development projects in designated areas. There is also a proposal to protect the delta under the Ramsar convention (Ramsar, Iran 1971). Alliances have been formed with several local communities that are in danger of being evicted in order to mount a court case.

An increase in land pressures for agriculture will lead to a strengthening of such 'uneasy alliances'. As a FAO paper points out (Aveling *et al* 1997), 'it could be said that pastoralism and wildlife both have *first-order conflicts* (fundamental incompatibility) with intensive agriculture, whereas they only have *second-order conflicts* (some constraints to compatibility) with each other.' Activists and pastoralists are strategising towards restricting the conversion of lands from pastoral to agricultural uses, minimising and mitigating second-order conflicts between pastoralists and wildlife management, such as predation, disease and grazing competition, and trying to maximize the positive and complementary aspects of pastoralism and conservation such as spreading economic risk and maintaining opportunities for ecological and cultural diversity (*ibid*). Economic pressures in the delta mean the Orma are also engaging in a range of other strategies, including developing market linkages with women entrepreneurs trading livestock products such as milk and 'labania' cheese. Pastoralists are marking off corridors to save from land grabbers — in essence 'grabbing' the corridors for themselves as a grazing/land protection strategy (Nunow 2010).

6. Conclusion

The acquisition of land by foreign land users, either through land leases or land purchases, is leading to the creation of new geographies of investment, production and consumption and the displacement of environmental burdens. This spatial displacement is labelled as 'tele-connections' which is defined as: 'the correlation between specific planetary processes in one region of the world to distant and seemingly unconnected regions elsewhere' (Erb at al 2009).

In the Tana Delta today the biomass appropriated by humans remains largely in the area, except for the charcoal sold to traders and some meat exports and cash crops, such as mangoes and bananas. In a sugar economy, biomass production would increase, the proportion appropriated by humans would increase even more, the Orma and the Pokomo would be dispossessed, less biomass would be available for the local 'wild' biodiversity, and a much larger proportion of the NPP would be exported as sugar or ethanol or even as electricity from bagasse. Many of the internal social conflicts can and should be interpreted with help from the methods for the study of social metabolism, bridging the divide between ecology and political economy in a (relatively) new political ecology. The new bio-economy, and particularly the new sugar economy, foresees highly increased production of biomass — yet more productivity does not mean more for everyone among the human species and across species. The re-assignation of rights to biological productivity and the incorporation of farmers and pastoralists into new agrarian structures transform not only social relations and accumulation strategies, but also reproduce nature with profound impacts on ecosystem energetics and corresponding livelihood strategies. This paper has focused on changes on biomass production and use in the Tana Delta as an enquiry into the question of biomass for whom, and at what environmental cost?

The World Bank Land Grabbing report (2010) classes much of Sub-Saharan African under a 'suitable land available, high yield gap' typology, arguing that cultivation in these areas could be massively intensified. According to the report moreover, more than half of the land area that could potentially be used for expansion of cultivated area is in ten countries, of which five are in Africa. The report does not indicate whether the projects it tracks are in fact to be under rain-fed or irrigated farming. Under the World Bank logic, closing the yield gap through transfer of land to more 'efficient users' (efficiency being measured in economic terms, disregarding the EROI), is the answer to the scramble for biomass resources. This paper has attempted to delve into some of the impacts on human livelihoods and biodiversity conservation at a local scale that such transfers will entail.

Moreover, this paper calls into question the barometer of 'productivity' as defined by the World Bank study and similar studies — based on monoculture and simplified energy-material relationships rather than on multi-use relations with complex feedback processes and complementarities. The concept of yield gap denies that existing land use may well be the most productive, equitable and sustainable, and that increased yields and intensification come at the cost of externalities and decreased energy-efficiency. The provisioning ecosystem services of increased productivity (food fibre and fuel provisioning for the global market) come at the expense of other environmental services not valued by the market that benefit local communities (Costanza *et al* 1997; Hamerlynck 2010). Furthermore, grand schemes to transform the African bush into bountiful 'Eden's' consistently ignore the embarrassing failures of past experiences.

Further research into the distributional impacts of changes in the distribution of biomass at local and global scales that land grabbing will lead to is called for. This paper has first analysed the 'old' conflicts between agricultural and pastoralists in the Tana delta in terms of appropriation of biomass for subsistence and other purposes. It has then traced possible scenarios of sugar cane production aimed at external markets, resulting in increased biomass production (because of irrigation and fertilisers) and also increased human appropriation of such biomass. Behind the statistics of social metabolism there are local groups of people; there are also new social alliances such as those between conservationists and pastoralists, between the cult of wilderness and the environmentalism of the poor.

This paper aims to contribute to work on local social metabolism analysis in the context of land grabbing leading to increased biomass production. What is needed are further analyses combining biophysical, economic, political-ecological, cultural, and geographical theories of land use that can elucidate trade-offs between local human subsistence needs, biomass availability for other species, carbon sequestration, bio-energy/ production and biodiversity and trade-offs between productive and other, priced and non-priced eco-system services transferred spatially through biomass trade (Haberl *et al* 2010).

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LDPI Convenors

Saturnino M Borras Jr is Associate Professor of Rural Development Studies at the International Institute of Social Studies (ISS), The Hague. He helps coordinate the work of the Initiatives in Critical Agrarian Studies (ICAS) hosted by the Resources, Livelihoods and Environment (RELIVE) Research Cluster at ISS. He was the Canada Research Chair in International Development Studies at Saint Mary's University in Halifax, Nova Scotia in 2007–2010 and an Adjunct Professor in the College of Humanities and Development Studies (COHD) of the China Agricultural University in Beijing. As a Fellow of the Transnational Institute (TNI) in Amsterdam, he is actively involved in its 'Agrarian Justice' Program. He is also a Fellow of Food First/Institute for Food and Development Policy in Oakland, California. Publications include: *Pro-Poor Land Reform: A Critique* (2007) and *Transnational Agrarian Movements Confronting Globalization* (2008, co-edited with M. Edelman and C. Kay). He has ongoing research projects on global land grabbing, biofuels and the politics of transnational agrarian movements. Email: borras@iss.nl

Ruth Hall is an Associate Professor at the Institute for Poverty, Land and Agrarian Studies (PLAAS) at the University of the Western Cape in South Africa. Her research interests include land and agrarian reforms, rural labour markets and farm worker rights, agricultural commodity chains, and the politics of rural development. She holds a DPhil in Politics from the University of Oxford. Publications include an edited volume entitled *Another Countryside? Policy Options for Land and Agrarian Reform in South Africa*; with Lungisile Ntsebeza, *eds*.; T*he Land Question in South Africa: The Challenge of Transformation and Redistribution*; and with Cherryl Walker, Anna Bohlin and Thembela Kepe, *eds*., *Land, Memory, Reconstruction, and Justice: Perspectives on Land Claims in South Africa*. She is Book Reviews Section Co-Editor of the *Journal of Peasant Studies*. Email: rhall@plaas.org.za

Ian Scoones is a Professorial Fellow at the Institute of Development Studies (IDS), University of Sussex, UK. He has a background in agricultural ecology and his interdisciplinary research links the natural and social sciences and focuses on the relationships between science and technology, local knowledge and livelihoods and the politics of policy processes. He has worked on issues such as pastoralism and rangeland management, soil and water conservation, biodiversity and environmental change, land and agrarian reform, dry land agricultural systems, crop biotechnology and animal health science policy, mostly in Africa. He is currently co-director of the ESRC Social, Technological and Environmental Pathways to Sustainability (STEPS) Centre at Sussex and Joint Convenor of the Future Agricultures Consortium. Key publications include: *Science, Agriculture and the Politics of Policy: The Case of Biotechnology in India* (Orient Longman, 2006) and *Land Reform in Zimbabwe: Myths and Realities* (James Currey, 2010). He is a member of the Editorial Collective of the *Journal of Peasant Studies*. Email: I.Scoones@ids.ac.uk

Ben White is Professor of Rural Sociology at the International Institute of Social Studies (ISS) and Professor of Social Sciences at the University of Amsterdam in the Netherlands. He is part of the Resources, Environment and Livelihoods (RELIVE) Research Cluster at ISS. He has carried out research on the themes of agrarian change, social differentiation of the peasantry, contract farming, rural labour, land policies, among others, mainly in Indonesia. He has published extensively on these themes. For seventeen years, he was co-editor of *Development and Change*, until mid-2009. Email: white@iss.nl

Wendy Wolford is the Polson Professor of Development Sociology at Cornell University. Her research interests include the political economy of development, social movements, land distribution and agrarian societies. Key publications include *To Inherit the Earth: The Landless Movement and the Struggle for a New Brazil* (co-authored with Angus Wright, Food First Books, 2003) and *This Land is Ours Now: Social Mobilization and the Meaning(s) of Land in Brazil* (2010, Duke University Press). She is a member of the Editorial Collective of the *Journal of Peasant Studies*. Email: www43@cornell.edu

LDPI Working Paper Series

A convergence of factors has been driving a revaluation of land by powerful economic and political actors. This is occurring across the world, but especially in the global South. As a result, we see unfolding worldwide a dramatic rise in the extent of cross-border, transnational corporation-driven and, in some cases, foreign government-driven, large-scale land deals. The phrase 'global land grab' has become a catch-all phrase to describe this explosion of (trans)national commercial land transactions revolving around the production and sale of food and biofuels, conservation and mining activities.

The Land Deal Politics Initiative launched in 2010 as an 'engaged research' initiative, taking the side of the rural poor, but based on solid evidence and detailed, field-based research. The LDPI promotes in-depth and systematic enquiry to inform deeper, meaningful and productive debates about the global trends and local manifestations. The LDPI aims for a broad framework encompassing the political economy, political ecology and political sociology of land deals centred on food, biofuels, minerals and conservation. Working within the broad analytical lenses of these three fields, the LDPI uses as a general framework the four key questions in agrarian political economy: (i) who owns what? (ii) who does what? (iii) who gets what? and (iv) what do they do with the surplus wealth created? Two additional key questions highlight political dynamics between groups and social classes: 'what do they do to each other?', and 'how do changes in politics get shaped by dynamic ecologies, and vice versa?' The LDPI network explores a range of big picture questions through detailed in-depth case studies in several sites globally, focusing on the politics of land deals.

Who Gets the Human Appropriation of Net Primary Production?

In this article we focus on the connection between purchases of land and the emerging 'biomass-economy', analysing biomass distribution in a region targeted for land-grabbing in order to understand the process from both bio-physical and political ecological perspectives. We narrow the focus down to a case study in the Tana Delta, Kenya, one of the new commodity frontiers in the recent large-scale land acquisitions, employing an indicator derived from social metabolism analysis — the Human Appropriation of Net Primary Production (HANPP). This allows us to examine biomass flows in the Delta, combining a biophysical perspective with a political-ecology analysis of the interests, stakes and power politics in the delta. The first section introduces the conceptual tools and theoretical framework, expanding on the concept of the 'sugar economy' as a socio-metabolic transition, and material and energy flow analysis (MEFA) as valuable instruments in gauging sustainability and potential sites of conflict over biomass. The second section contextualises the case study of the Tana Delta in Kenya as a site of conflict over biological resources through an analysis of property rights and historical dynamics. The third section presents the results of the analysis of biomass distribution. The fourth and fifth sections offer discussion of the results and the conclusions.

Land Deal Politics Initiative
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landpolitics@gmail.com

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