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Regulation Theory and Socioeconomic Metabolism to characterize economy-wide degrowth patterns: the case of Special Period Cuba.

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I seek to positively understand the institutional patterns behind system-wide, voluntary metabolism restructurings like degrowth. While economy-wide degrowth is not observable in all of its dimensions, specific aspects can be informed in certain cases. Cuba during the "Special Period" in the 1990s is an example where a drastic metabolism reduction was partly decoupled from progress in social indicators. To integrate socioeconomic and biophysical analysis—still lacking in degrowth research— I combine regulation theory and socioeconomic metabolism. I also introduce a new type of Sankey diagram that incorporates non-technical information external to the datasets. In the Cuban case, initial institutions such as planning, rationing, extended social security, and the absence of hegemonic market relations proved pivotal—though ultimately insufficient—in managing living conditions under biophysical contraction. Further adaptations included State support for grassroots initiatives, partial polycentrization of the planning system or double-track mechanisms combining planning and markets. The absence of democracy, however, precluded systemic post-growth change, lending empirical support to one of the core hypotheses of degrowth theory. These elements are synthesized within the regulation theory framework to suggest that a degrowth mode of production may imply basic needs logics instead of market social relations. Degrowth regimes likely imply planning and only partial decentralization. The diversity and specific features of degrowth-compatible modes of regulation remain open to debate. Further comparative research within the provided framework is needed to refine the characterization of such socioeconomic and biophysical regimes.

1. Introduction

Scholars define degrowth as "*an equitable downscaling of production and consumption that increases human well-being and enhances ecological conditions at the local and global level*" (Schneider et al., 2010), or "*a planned reduction of energy and resource use designed to bring the economy back into balance with the living world in a way that reduces inequality and improves human well-being*" (Hickel, 2020). They stress the need for a "*radical political and*

economic reorganization" (Kallis et al., 2018) to achieve "*a society with a smaller metabolism, but more importantly, a society with a metabolism which has a different structure and serves new functions*" (D'Alisa et al., 2014). So far, the mostly apolitical implemented transition policies have not steered capitalist economies toward a "safe and just operating space" (Haberl et al., 2020; Hofferberth, 2025; Kemp-Benedict, 2025; Raworth, 2013; Rockström et al., 2009). By examining how socio-political structures hinder or enable sustainability, degrowth is gaining traction in academic debates, though less in the public sphere (Drews et al., 2019; King et al., 2023).

Degrowth research outlines trajectories out of environmental unsustainability but requires further clarifications (Cosme et al., 2017; Fitzpatrick et al., 2022; Savin and van den Bergh, 2024). The specific delineation or the key features of a degrowth society (and conversely, the potential diversity of such societies) remain a topic of theoretical speculation. How societies might behave once degrowth begins also remains unknown. What might degrowth trajectories, institutional changes, and enabling conditions look like? In short, the challenge is to strengthen knowledge of what degrowth-like metabolic reconfigurations mean in terms of political economy. Better understanding is crucial to assess socioecological trajectories and guide economic and political change. Clearer degrowth characterization means a better grasp of the politics of lighter metabolisms.

This article addresses this gap through a large-scale real-world case study. First, the value of real-world cases is well established. Kallis et al. (2022, p. 2) lay out a research program based on the analysis of "*real-existing degrowth*" cases, in opposition to "*the plethora of idealised, normative ('utopian') models put forward in some degrowth literature*". Real-world cases reveal unanticipated dynamics. They also highlight the context-specific and diverse nature of future degrowths. Second, real-world case studies of degrowth exist, but in vast majority as small-scale, local studies of alternatives. Previous studies stress the need to study degrowth at larger scales: Durand et al. (2024, p. 2) identify a "*localism*" bias in their review of the degrowth literature, as do Savin & van den Bergh (2024, p. 14). Analyzing case studies at a meso or macro scale helps to understand institutional or metabolic dynamics unobservable at smaller scales. Even if such real-world cases only partially fits the degrowth definition, they offer insights into partial dynamics and features.

A key example is Cuba during the 1990s "Special Period," which shares features with expected degrowth. It is a unique limit case of socioeconomic downscaling linked to improved social indicators (figure 1). Following the collapse of the USSR, the island faced dramatic biophysical constraints, most crucially on oil imports. Yet Cuba's economic restructuring unfolded in unexpected ways compared to the typical patterns of depressions or recessions in Northern capitalist economies. The period is best known for its large-scale transition to agroecological farming, but it also saw a strengthened commitment to public health or food provisioning—albeit with mixed results amid broader macroeconomic upheaval. Figure 1 illustrates how Cuba achieved comparable trends and outcomes in life expectancy or infant mortality, with substantially lower—and in some cases even declining—levels of material throughput and environmental pressure than the United-States, as

reflected in similar Planetary-Adjusted Human Development Indexes. Special Period Cuba has already been studied, in particular with regards to agroecological conversion (Funes et al., 2002; Pfeiffer, 2006; Wright, 2009), but also in general (Brundenius and Torres Perez, 2014; Eckstein, 2004; Mesa-Lago, 2005). However our threefold research question—institutions, metabolism, and degrowth—is new to this literature. One study has focused on the Cuban socioeconomic regime from an institutional economics perspective, unfortunately stopping in the middle of the 1990 period (Larifla, 1995). A few papers have related Cuba to degrowth (Bayler, 2018; Boillat et al., 2012; Borowy, 2013), while not specifically engaging in a comprehensive statement of the biophysical side of the transformation. The rich study by Santiago Muíño (2016) dives deep into sustainability issues, but does not conduct metabolic analysis. Conversely, one study examines Cuban metabolism (Eisenhut, 2009), but it does not address the relation to the socioeconomic structure, nor is it degrowth related. Here I present a new characterization of the Special Period socioeconomic regime and metabolism, centered around observed institutional change and how it relates to biophysical reconfigurations. The Special Period mixed successful adaptations with social disorganization. This explains why it is a contested case, cited as proof of socialism's or ecology's failure, or as a model of sustainability. I use the agrofood sector to show metabolism was smaller but also differently structured and purposed.

Since real-world cases only partially fit degrowth definitions, extracting the most out of it is a matter of methodology and theoretical framework. I analyze it through a framework combining the Regulation Theory approach of institutional economics with the Socioeconomic Metabolism paradigm, to adequately account for both social and environmental aspects (Cahen-Fourot and Magalhães, 2023). To link quantitative throughput and institutional change, I represent the Cuban transformations in a special type of Sankey diagrams that incorporate socioeconomic features. This concretization of the framework highlights the shift from one mode of production towards another.

2. Methodology and data

2.1. Linking Regulation Theory and social metabolism analysis

Regulation Theory (RT) is an institutionalist political economy approach offering an analytical and heuristic framework to characterize economic regimes (Boyer and Saillard, 2001; Labrousse and Michel, 2017; Aglietta and Fernbach, 2001; Amable and Palombarini, 2009). It could be closely related to historical neo-institutionalism (Hall and Taylor, 1996), placing social heterogeneity and conflict at its core. *Institutions* are sets of socioeconomic rules and norms. A central RT question is how coherent regimes emerge and persist despite contradictions—how specific *modes of regulation* arise. The term *regulation*, as opposed to the notion of equilibrium, describes how a social system can ensure an evolving, temporary, and situated stability under internal and external pressures. Different regulation modes may succeed to one another in supporting an *accumulation regime*.

Institutional forms are the situated expression, differing in time and space, of fundamental social relations : the relation between debtors and creditors defines the monetary regime ; the relation between corporations defines the competition regime ; capital and labor for the wage labor nexus ; producers and users of natural resources for the environmental social relation ; State and the economy for the State-economy relation ; nation-States relations for the international insertion. Defining the specific incarnation of the institutional forms for a given economy delineates its core rules: how contradictions are "fixed" to allow for the system's reproduction. This is linked to the concept of *institutional compromise* : temporary agreements that settle conflicts on specific issues. Compromises are not bound to be fair ; they engrave a certain relationship of power between different social groups or classes.

The RT framework provides a basis for analyzing degrowth regimes. It is also designed for comparative studies and thus enables future case studies to be capitalized upon. Conversely, the socioeconomic metabolism (SEM) paradigm (Pauliuk and Hertwich, 2015) is the logical framework to address the biophysical basis of society. SEM is open to interdisciplinarity to substantiate its analysis of social structures (Pauliuk and Hertwich, 2015, p. 8). I combine them into a joint analysis of degrowth, as both offer system-wide, long-term perspectives with systematic, heuristic tools. Cahen-Fourot & Magalhães (2023) and Pellegris & Court (2025) have notably put together a similar analytical framework, the former laying out the "*accumulation - metabolism nexus*" concept. Both papers do so in an analysis of capitalism, while I apply it to degrowth questions. Degrowth and RT have also been linked, without a metabolism framework (Durand and Légé, 2013; Koch, 2018).

2.2. Merging institutional and biophysical information in one Sankey diagram

Standard Sankey diagrams of input–output tables are constrained by database structures, showing only embedded "technical" categories. In the case of representing socioeconomic metabolism, the aim is to show how physical flows and social structures co-determine each other at a given time and place, but also to compare how the determinants of throughput structure evolve. This means that I use public databases combined with literature on how flows are distributed in society. I use the production and imports figures from the databases on one side, exports and consumption on the other, and assemble flows and nodes in between according to the structure I wish to represent. When major institutional changes occur, flow size *and* structure shift accordingly. However, there is a trade-off between what one wants to represent and what we have quantitative information about. They are thus ideal-typical Sankey diagrams, that can for example encompass information from one year prior or after the ideal-typical dates. Their value lies in illustrating orders of magnitude and structure; quantities should be interpreted cautiously.

2.3. Data

2.3.1. Energy and global metabolism

For the broader picture of Cuba's metabolism, I use the United Nations global material flows database, and the IEA world energy balances database. Here, I do not modify the Sankey diagrams structures.

2.3.2. Biomass

The agrofood metabolism presented in the paper is based on FAO figures from the Food Balances. Cuban government figures exist but are widely considered overly optimistic (Mesa-Lago, 1998, p. 7; Wright, 2009, p. 100). The FAO production figures "*relate to the total domestic production whether inside or outside the agricultural sector, i.e. it includes non-commercial production and production from kitchen gardens*" (FAO documentation). This is especially useful since we wish to capture both informal and official production. FAO statistics are expressed in ktons, fresh weight. It is the simplest unit for modifying Sankey diagram structures (using C, N or embedded energy would require unavailable information on the exact type of products going through each newly created node).

The only modification to the original data concerns the "vegetables, other" series. In the early 2000s, it spiked sharply for a few years before plummeting back. In the technical appendix, I present the different sub-components of the series. The "feed" sub-component is the source of the surge, while the "food" sub-component behaves plausibly. Upon solicitation of the FAO, it was confirmed that only the "food" sub-component should be used, which I applied.

Fertilizers data also comes from the FAO Inputs statistics. They subsume chemical and mineral fertilizers, synthetic or not. In Cuba the drop in fertilizers use is almost exclusively driven by imported, synthetic ones.

2.3.3. Sankeys' "social" structure

I use the available literature to infer quantitative constraints on flows. The main sources are field work literature on the agroecological changes in Cuba, which contain significant information on various aspects of production, distribution and food consumption in Cuba (Pfeiffer, 2006; Santiago Muíño, 2016; Wright, 2009). I report all the hypotheses and subsequent sources in the supplementary material tables. Using a reconciliation algorithm, I am able to overcome partially lacking data if needed (Courtonne et al., 2016, 2015).

Fertilization is a key driver of agro-food reconfigurations, but it was not possible to use N as the Sankeys unit. There is not enough information on how the subsequent N flows are dispatched in the modified structure I want to create. The amount of fertilizers is thus only represented as a standalone flow. Note that it is not to scale with the rest of the biomass flows, otherwise it would be negligible and variations unobservable.

3. The institutional change associated to Cuba's shrinking metabolism

3.1. The Cuban biophysical and socioeconomic regime before 1989 and the Special Period

The institutional context before the Special Period shaped its reconfigurations. In 1989, Cuba's accumulation regime was built on outward-oriented material flows. It was an assisted rentier economy, reliant on sugar production (Larifla, 1995). Sugar ensured high and stable revenues of a triple nature, via Cuba's inclusion in the Council for Mutual Economic Assistance. It ensured artificially high export prices (indirect subsidy); artificially low import prices for fuel bought with sugar earnings; and development credits from socialist countries that sustain sugar production. This rent was political, since it depended on the USSR strategic interest of supporting Cuba. The assisted rentier nature is visible in a metabolism dominated by biomass and externally oriented (figure 3, before Special Period). This openness reflected both "rent" (exports) and "assistance" (imports). Cuba's material wealth depended on sugar-financed imports—machinery, consumer goods, agricultural equipment, and technical assistance—from the socialist world. Most notably, Cuba's energy—especially oil—was largely imported (figure 4).

The socialist regime displayed its characteristic "institutional base" (Chavance et al., 1994): State property (with Cuba displaying an unusually high 97% collectivization rate) and a single party as stable institutions, with planning as an adaptable one. The planning system evolved internally, shifting from authoritarian to "consensual" paradigms with ideological changes in the Communist Party (Larifla, 1995). The single party enjoyed strong popular support, largely due to the revolution's egalitarian gains. Castro's legitimacy was thus tightly linked to socioeconomic performance–this formed a central *institutionalized compromise* (Boyer and Saillard, 2001) in the Cuban system. Despite this, the regime remained a single-party dictatorship, which would become problematic as living conditions worsened and State–citizen tensions grew, challenging past social compromises.

Cuba's mode of regulation was characterized by shortages, typical of socialist systems (Chavance et al., 1994), with input competition for firms, informal production, and monetary retention among individuals. Sectoral shortages stemming from investment cycles were part of normal endogenous dynamics.

In 1989 the institutional architecture of the economic regime can therefore be summed up as follows (figure 2). Some institutional forms dominate others because they embody compromises vital to regime coherence. Here the international insertion plays a dominant role as key to institutional stability. I represented the "social pact" which is a central institutionalized compromise, partly structured around the idea of continued economic accumulation. Like other institutional forms, environmental relations depended on international insertion. For instance, sugar's rent-based role in redistributing income meant that land and biodiversity were exploited via intensive monoculture, despite ecological consequences. The primacy of international insertion is also visible in the

exports and imports role in the island's metabolism (figures 3 and 4). The self-reproduction and coherence of the regime rests on a mode of regulation through shortage (Chavance et al., 1994).

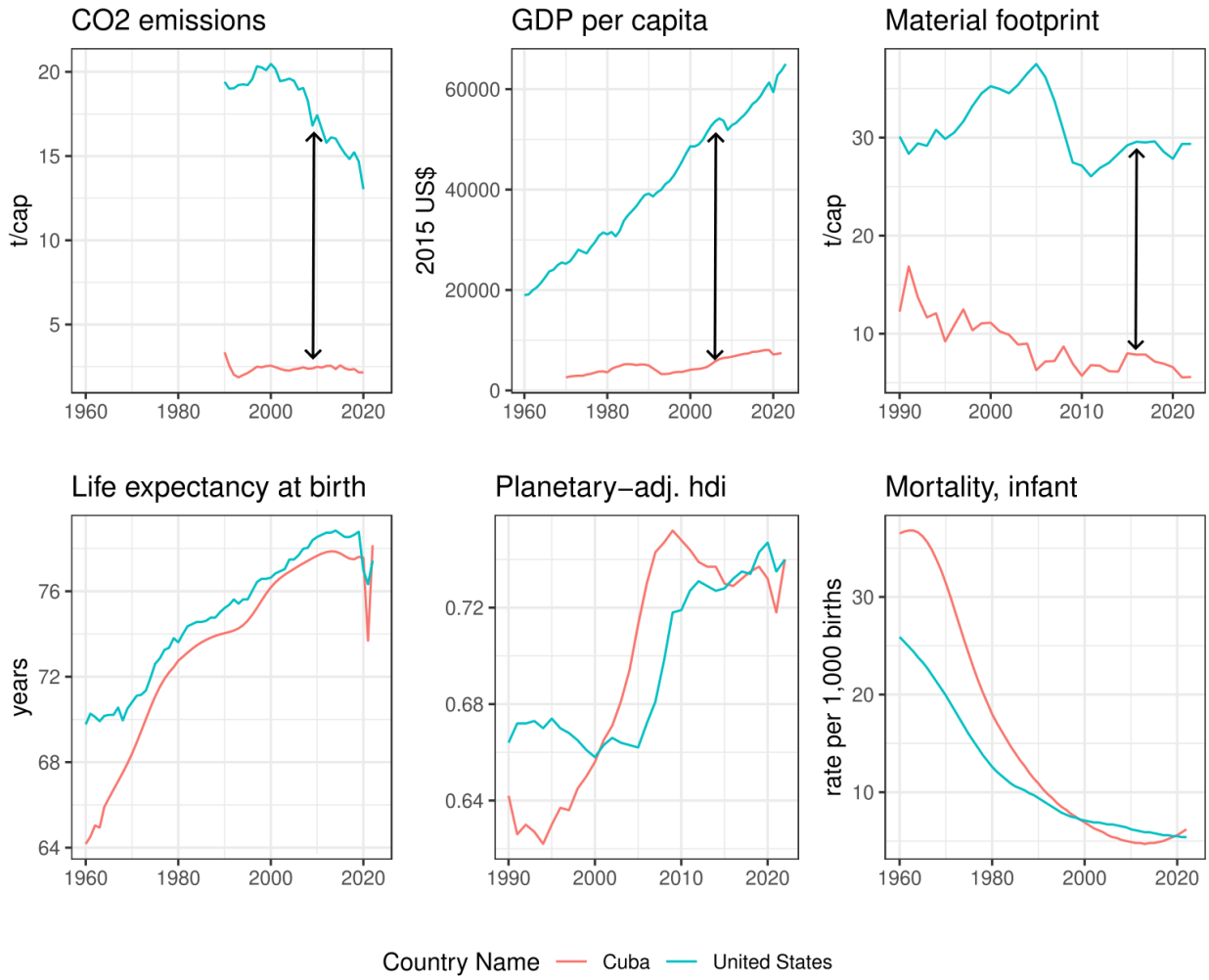


Figure 1: Cuba compared to the United States on biophysical, economic, social and health indicators from the World Bank

Cuba matches and sometimes surpasses US planetary-adjusted Human development Index and health figures, with ten times less CO2 emissions and two to three times less material footprint. Progress in these indicators seems unhindered by the severe biophysical downscaling of the 1990s (figure 3).

Source : World Bank. PHDI is "*the level of human development adjusted by carbon dioxide emissions per person (production-based) and material footprint per capita*" (World Bank).

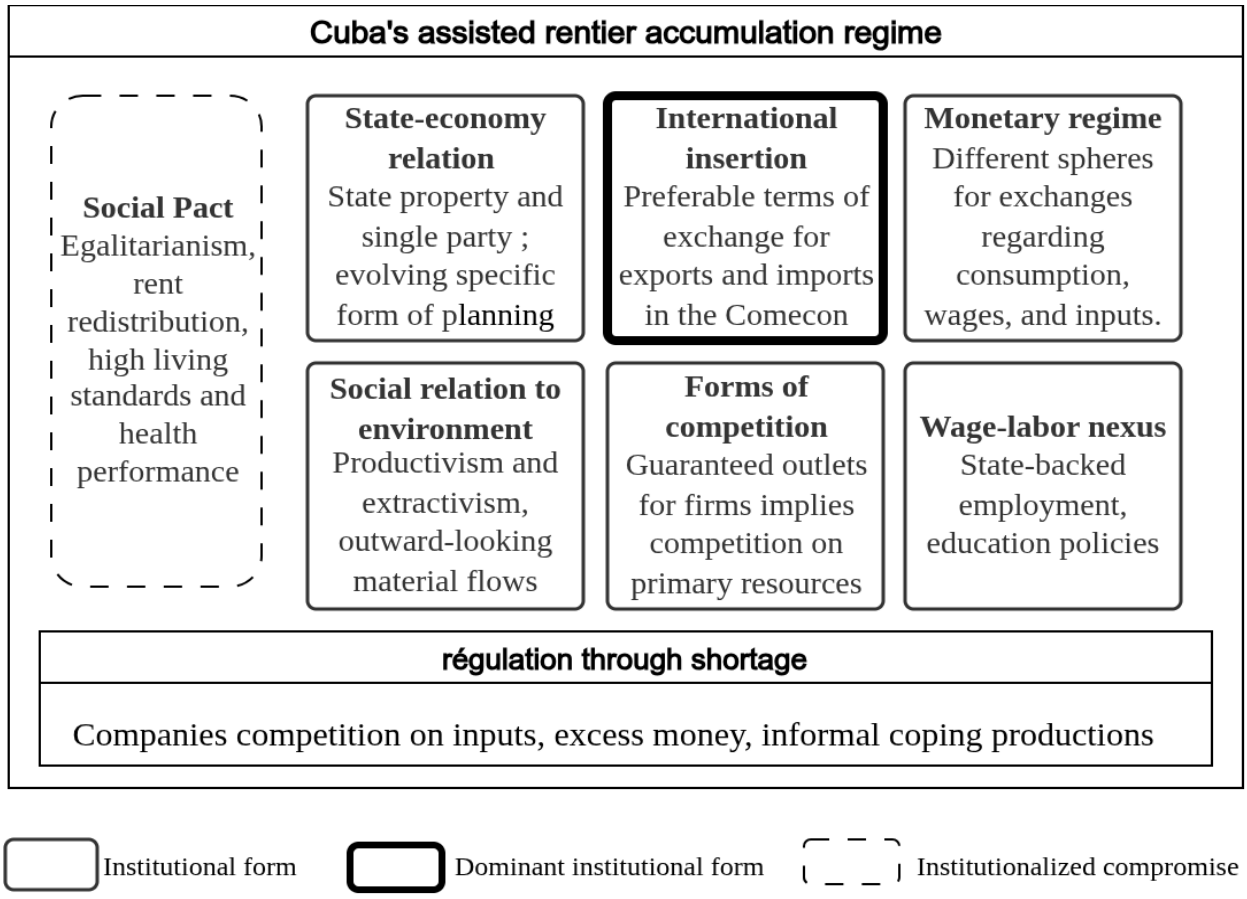


Figure 2: Institutional structure defining the accumulation regime in Cuba prior to the Special Period

A growth-dependent rentier accumulation regime where international flows are crucial,. It is held together by a central institutionalized compromise in which improvement in the living standards justifies the socialist State.

The regime's biophysical and political bases were entirely challenged by the USSR's collapse, which ushered in the "Special Period". As can be seen quantitatively, the centrality of the international insertion plays to its fullest when biomass exports and energy imports both plummet (figures 3 and 4). This metabolic-institutional crisis sets a new context, where continued improvement in some social indicators (figure 1) may seem puzzling. The agro-food sector illustrates how this was possible.

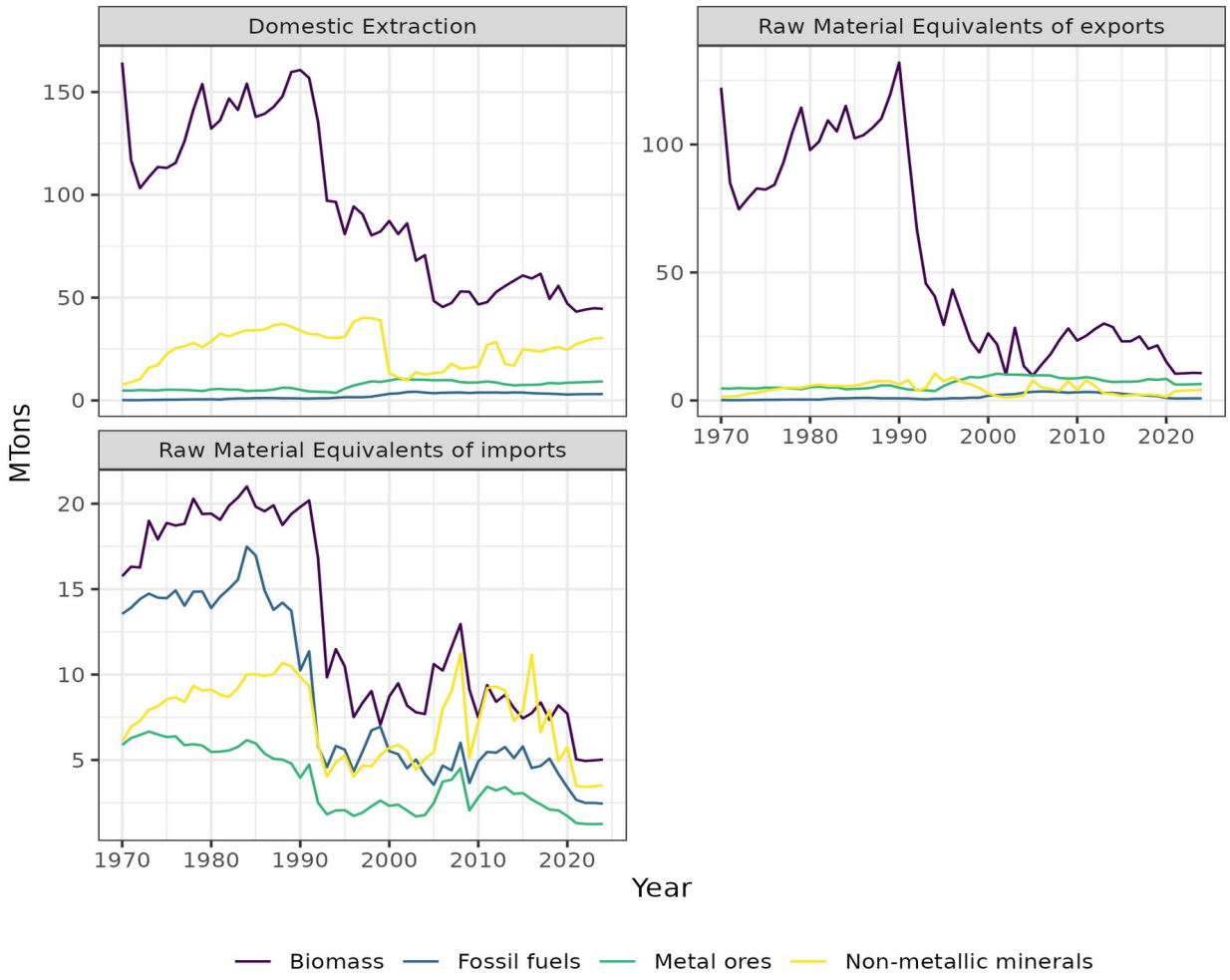


Figure 3: The metabolism downscaling underwent in Cuba since 1989, following the fall of the USSR and the continued enforcement of the U.S. embargo. Note that *y* scales are not comparable.

Source: United Nations Environment Program, International Resource Panel, Global Material Flows Database.

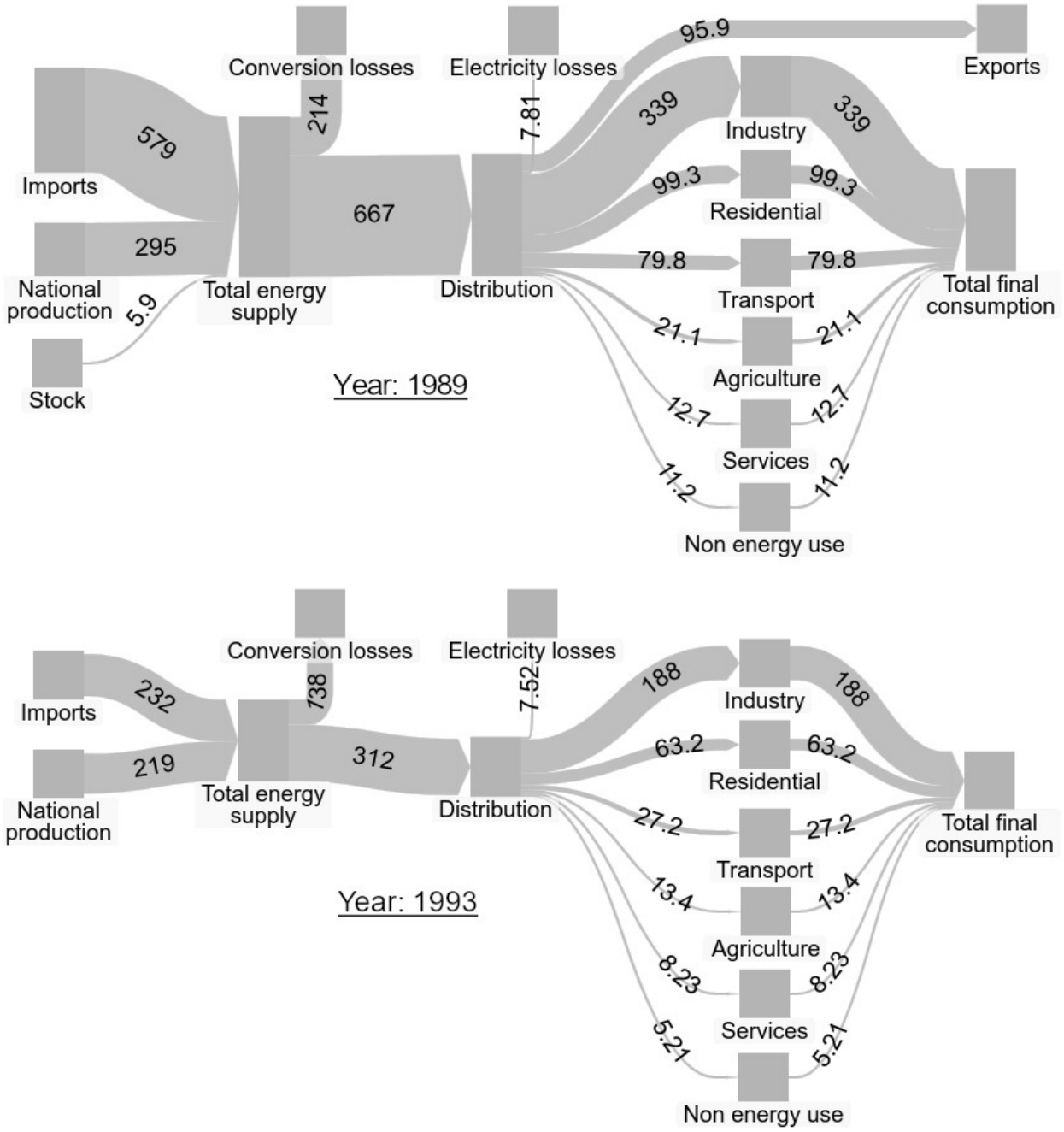


Figure 4: The biophysical contraction in Cuba seen through the energy metabolism: 1989 (top) *vs* 1993 (bottom). Unit: PJ.

Energy flows are halved between 1989 and 1993. The reduction is primarily imports-driven. This causes economy-wide repercussions with industry and transport as the most impacted sectors. Even national energy production decreases as a consequence of the general upheaval.

Source: IEA World Balances, Author

3.2. The agrofood provisioning system changes and the emerging socioeconomic metabolism

Three Sankey diagrams describe biomass flows for three ideal-typical years: 1989 ("before the SP", figure 5), 1994 ("peak of the SP", figure 6), 1999 ("end of the SP", figure 7). For the reader's comfort, a Side-by-side comparison of biomass metabolisms is added in the appendix. Table 1 summarizes key quantitative shifts. Overall, metabolism was downscaled–but more crucially, restructured and repurposed. Sugar industry contraction concentrated the reduction (table 1); yet it was preserved symbolically, as the central government and Communist Party refused to reassess the assisted rentier regime. Sugar production fell primarily due to the loss of inputs (from oil to synthetic fertilizers), but also because of specific policies for land reallocation. It should be noted that for islands with similar agricultural features like Mauritius or La Réunion, severely downscaling the monoculture and productivist sector has been pointed out as the key to achieving sustainable systems (Billen et al., 2024; Serrano-Tovar, 2015). The shift in production modes is a reaction to the almost complete halt in synthetic fertilizers availability due to import losses, as well as energy scarcity. The key drivers of change were decentralization, urban farming, agroecological practices backed by the State and scientists, and partial marketization. These improved food production and access, while sharply reducing input use; but each had distinct effects.

Table 1: Synthetic indicators and ratios on Cuba's metabolism during the Special Period, based on figures 2, 5, 6 and 7

	1989	1994	1999	1989/1994	1994/1999	1989/1999
Industrial energy consumption (TJ)	338476,2	191716,3	248659,3	-43%	30%	-27%
Agricultural energy consumption (TJ)	21085,1	13560,2	13310,2	-36%	-2%	-37%
Biomass production (kt)	86300	47000	41700	-46%	-11%	-52%
Sugar cane transformed (kt)	73800	38200	32800	-48%	-14%	-56%
Biomass domestic consumption (kt)	8900	6080	8490	-32%	40%	-5%
Biomass exports (sugar) (kt)	7670	3290	3550	-57%	+8%	-54%
Informal biomass sector (kt)	1210	2400	3380	+98%	+41%	+179%
Biomass private farmers production (kt)	2160	1880	2500	-13%	+33%	+16%

Sugar production relative to production	0,86	0,81	0,79	-5%	-3%	-8%
Sugar production relative to consumption	8,29	6,28	3,86	-24%	-39%	-53%
Biomass consumption relative to production	0,1	0,13	0,2	+25%	+57%	+97%
Biomass exports relative to production	0,09	0,07	0,09	-21%	+22%	-4%
Biomass exports relative to consumption	0,86	0,54	0,42	-37%	-23%	-51%
Informal biomass consumption relative to consumption	0,14	0,39	0,4	+190%	+1%	+193%
Informal biomass consumption relative to production	0,01	0,05	0,08	+264%	+59%	+478%
Private biomass production relative to production	0,03	0,04	0,06	+60%	+50%	+140%

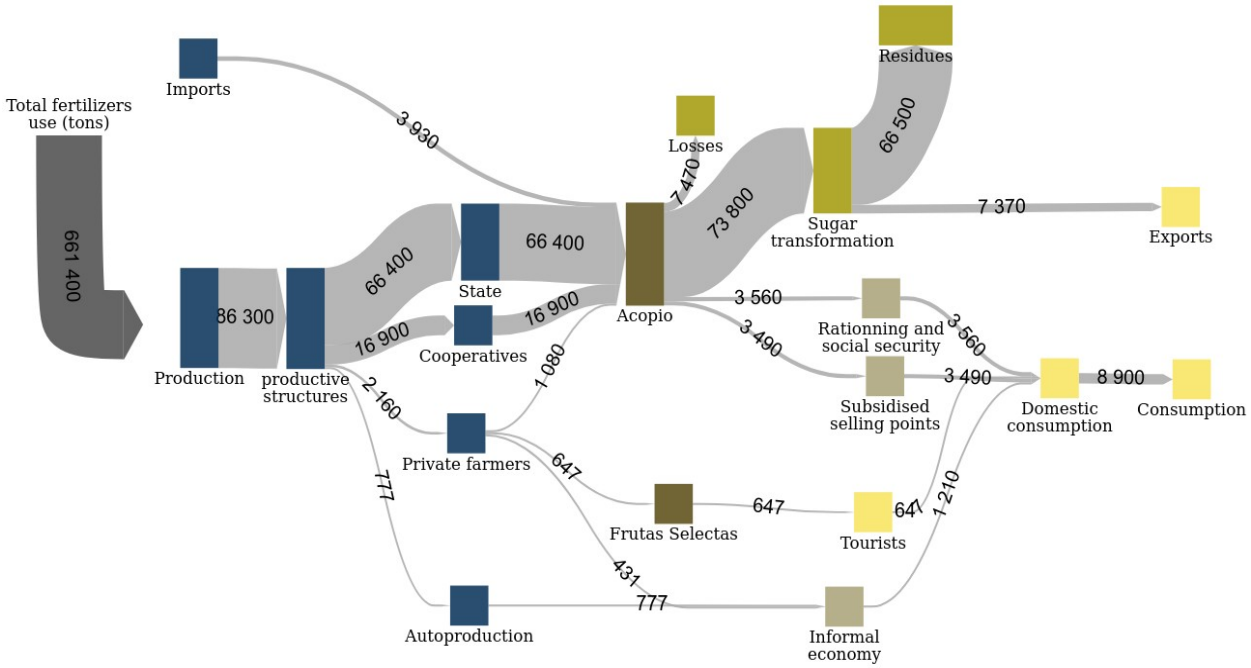


Figure 5: Biomass metabolism in 1989 (kt, fresh weight)

The dominant factor in the country's metabolism is sugar cane production and transformation, which is managed by State farms and the state-owned collection-distribution company Acopio. Imports play a significant role when compared to final consumption, and are redistributed through the rationing system. Food is either procured through uncommodified official channels or through the informal economy, including on-site farming (fairly residual) and the black market.

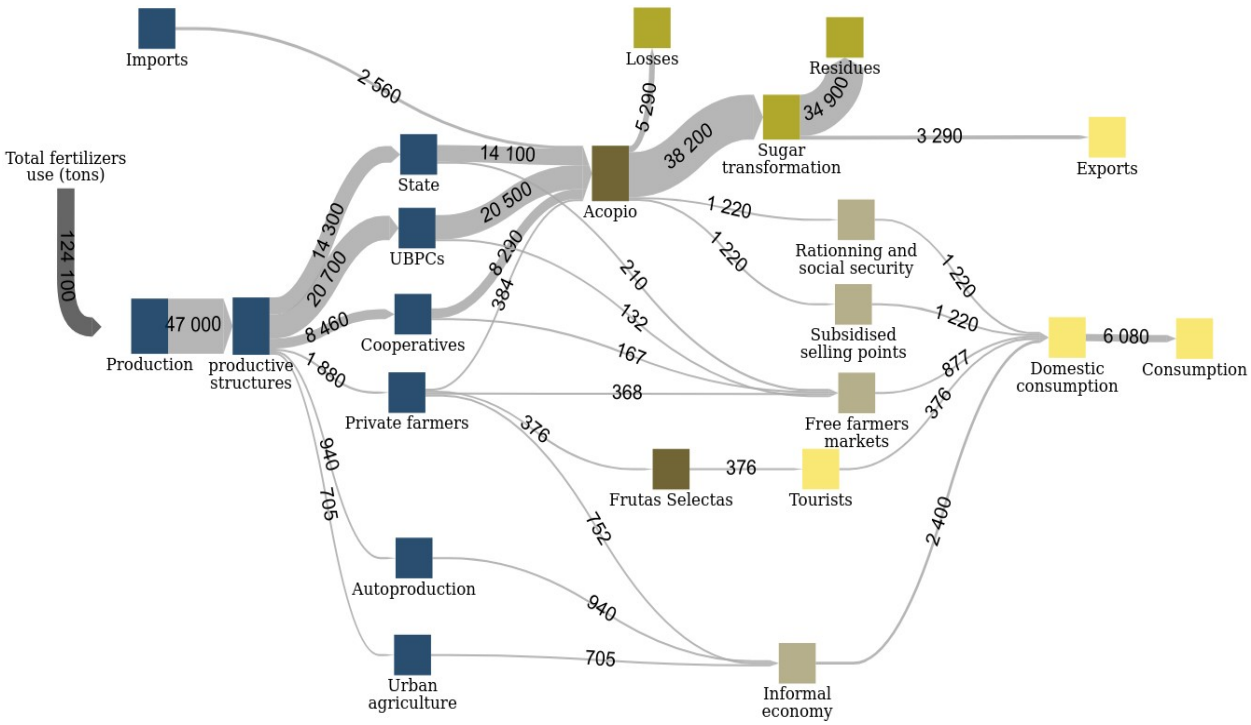


Figure 6: Biomass metabolism in 1994 (kt, fresh weight)

Production dropped, especially sugar cane, and domestic consumption also declined. Daily rations became insufficient. Urban agriculture emerged as a key part of the informal economy, which now represented a large share of consumption since the official centralized system is disorganized. Free markets had just been reauthorized as an alternative to the Acopio system.

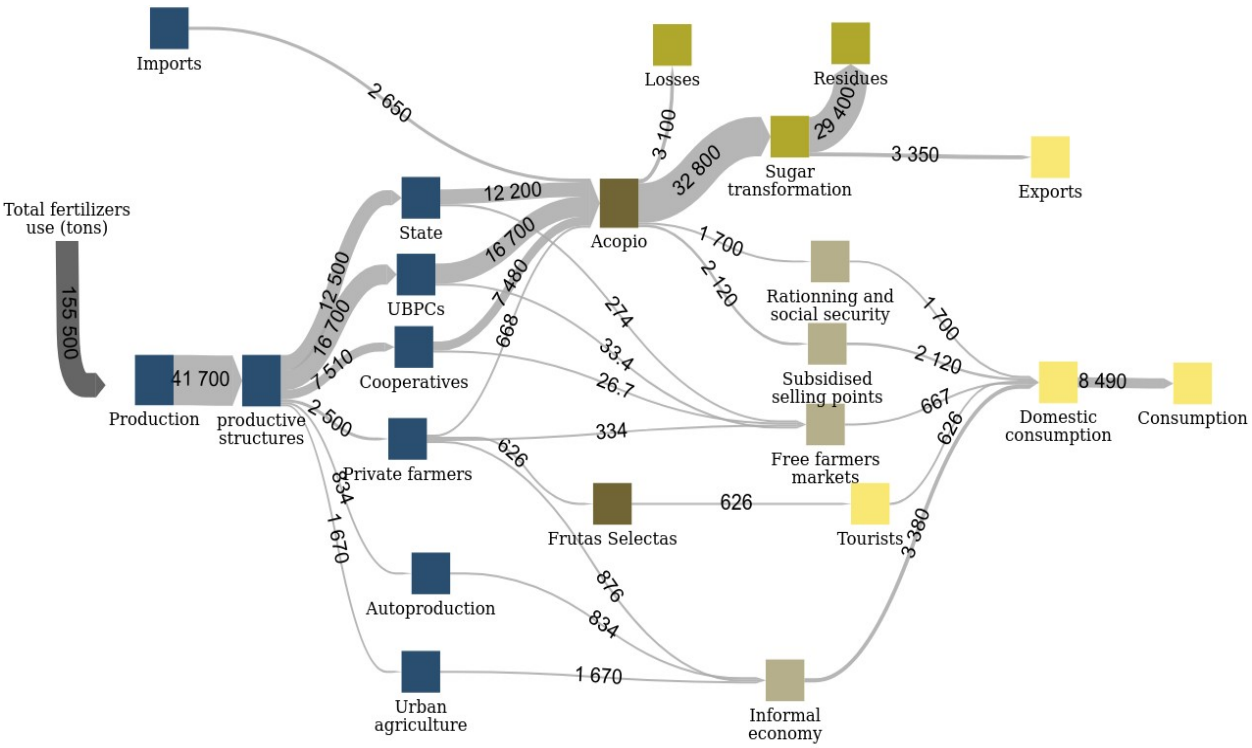


Figure 7: Biomass metabolism in 1999 (kt, fresh weight)

The production of sugar cane did not resume. Consumption recovered, notably through urban farming, a pivotal provider of vegetables. Tourist consumption rose due to government policies and dollarization. Private farmers' contributions to the informal economy also grew. They represents the black market. Imports remained significant in final consumption.

3.2.1. Decentralization and centralization

First, biomass flows through the central planning system (Acopio) decreased substantially (figure 5 and 6). Why did this happen, how did it shape the crisis outcome, and does it suggest degrowth entails decentralization?

Different forms of decentralization occurred during the Special Period and can be linked to the objective of efficiency improvement and the inability of the centralized planning system to cope with the general disorganization.

First, the State issued land reforms to transform large State farms into cooperatives (*Unidades basicas de producion cooperativa*, UBPCs in figure 6) and gave land usufruct to rural workers for their own consumption ("autoproduction", figure 6). This was the *plan alimentario*. In total, 41.2% of State land was transferred to 122,000 farmers in the form of 2,007 new cooperatives (Pfeiffer, 2006, p. 59). It was intended to solve productivity and idleness issues, the vast State farms being overwhelmed by the disorganization following

the generalized shortages. UBPCs and State farms continued to be mostly centered around sugar cane exploitation and therefore concentrate the strongest dip in biomass production in figure 6. The total flows from the “informal economy” node increase, and autoproduction on its own rises from around 770 to around 900 kt. This informal growth responded to the collapse of formal supply systems. This policy of on-site personal farming was also encouraged by the State, as a mean of retaining the labor force in the fields. Reforms also strengthened provincial and municipal levels, transferring responsibilities away from the central State. Wright (2009, p. 176) also reports that the ministry of agriculture underwent severe downsizing starting from 1994.

Second, urban agriculture could also be understood as a major form of production decentralization. The urban agriculture phenomenon begins to spring around 1994 (figure 6), and becomes central in the Cuban food provisioning system (figure 7 and table 1). Its quantitative size (around 1600kt) may suggest only a humble contribution to the total. But urban agriculture provides a very specific production that has historically been lacking in the Cuban national production: vegetables. The improvement in national consumption between 1994 and 1999 (6080kt to 8490kt in figures 6 and 7) is mainly the result of the increase in the informal economy, either from urban agriculture or from the black market, represented by the flow from private farmers to the informal sphere. As we will see, it is a result of grassroots initiatives combined with government support.

Third, decentralization also takes place at the distribution level: provincial agricultural delegation would coordinate Acopio’s actions to meet local needs in priority with local production (Wright, 2009, p. 107). Production and collection planning was thus partly carried out at provincial level, within the Ministry of internal trade and the Ministry of Health, and in conjunction with the Institute for internal demand, on the basis of local production forecasts based on information at the municipal level and passed up the chain. Based on this data, Acopio was responsible for planning inter-provincial rebalancing (Wright, 2009, p. 107). Only a few crops were excluded from this province-based planning, due to their national importance.

However, the picture would not be complete without accounting for the continuation, and even reinforcement, of some centralized mechanisms. There still is interference of the CCP instances in companies, and the State supports initiatives by giving resources, training and science support, but also by integrating them into its official structure. This is the case when the ministry of agriculture takes control over the emerging organic movement of peasants. The broad economic strategy is also still centrally determined: central plans are still issued, and State entities are still active inside companies to control production and food security. Similarly, while urban agriculture was initially unanticipated by the government, it quickly officialized the process in its own interests (not to be overwhelmed by spontaneous adaptations, both in practice and in discourse). In fact, urban agriculture even became almost compulsory (Wright, 2009, p. 88).

Urban agriculture is an example of this continuation of State support, which came in two forms: the allocation of land on the one hand, and the provision of technical support on the other (Wright, 2009, p. 88). This help is one of the main explanations for the rise of urban production in the overall biomass metabolism (nearly doubling from figure 6 to 7). A new law allowed residents to claim up to a third of an hectare in exchange for cultivation according to the rules of organic farming (resolution 527 of 1997). A department was set up in 1994 specifically to supervise and support these practices: the Urban Agriculture National Department, depicted as the "*supervisor of urban agriculture efforts in Cuba*" in (Brenner et al., 2014, p. 608). Made up of scientists as well as ministerial representatives and urban farmers, it oversaw sub-programs and had the task of directing developments in the sector as a whole (Wright, 2009, p. 88). It worked with the municipal authorities to allocate unused space. Since 1995, it had also been offering technical assistance services at neighbourhood level, through two channels: seed houses (*casa de semillas*) and producers' shops (*tienda del productor*) grouped under the umbrella of "*granjas urbanas*" that provided pathogen diagnostics, free advice, seeds, soil analysis, organic fertilizers, and tools (Borowy, 2013; Clausen Clark et al., 2015; Wright, 2009).

The resulting system is a mixed picture between centralization and decentralization, "*well suited to the task of overseeing an urban food production system that has as its guiding principle the need to decentralize food production without losing control and to centralize only to a degree that does not kill local initiative*" (Brenner et al., 2014, p. 610). The decentralization seemed inevitable in the sense that the central power did not have the ability anymore –if it ever had– to effectively coordinate the production. It was pivotal in the emergence of trial-and-error alternative modes of production and agricultural techniques. Pandey (2019) analyzes that the decentralization process in Cuba has been much more effective than Indian agricultural reforms, by harmonizing productions with their local environments, and thus achieving overall greater food security. Wright (2009, p. 103) finds that the central oversight on decentralized production decisions enabled quick coordinated adjustments, which was for example needed to control the *Thrips palmi* pest outbreak. State support also means faster development and institutionalization of alternatives. Yet, the persistence of the central apparatus also meant that bureaucracy and institutional staff remained a key class with a power over economic decisions, especially in favor of sugar production. Their involvement in production decision was wide and frequent, and farmers did not believe they were fully autonomous. This social class therefore played a lock-in role in the previous economic structure.

3.2.2. Markets and planning: A Cuban double-track?

One key transformation during the Special Period was the return of markets. As shown in figure 6, free farmers markets (re)appear, alongside a growing black market (with farmer-to-informal flows rising from around 400 to around 700kt). In 1989, food commodification had been banned after the "farmers markets" and the "rectification" phase, explaining their absence in figure 5. Their reappearance is caused by the shortages in the rationing system (figure 5 *vs* figure 7). This distribution channel was crucial in Cuba: the *canasta básica* had

ensured equal food access and underpinned the regime's legitimacy and "social pact" (figure 2). As explained by Larifla (1995), the material success of the revolution was a source of legitimacy for Castro. The *canasta basica* played a major role in it, ensuring an equal basic access to food, without equivalent in Latin America. But the ability of this system to satisfy basic needs is precisely what is at stake in the Special Period. The loss in imports (from around 3900 to around 2500kt, compared to around 6000kt of national consumption in figure 6), on which it relied, meant that monthly rations barely covered one week (Bayler, 2018; Mesa-Lago, 2009).

Should we conclude that markets enabled shrinkage, or that planning failed? First, Cuban farmers' markets differ from capitalist ones: only producers may sell, and State vendors regulate supply. Second, the black market is a common feature of regulation through shortage in socialist economies. However, it is true that the rationing system was overwhelmed, that people as well as farmers were asking for the reauthorization of food markets, and that the ability to sell plan surplus at higher prices boosted production (as was common in socialist economies, but in Cuba was State-backed). This was less about marketization than diversification of distribution channels. A more flexible, partly decentralized system improved spatial and temporal matching of supply and demand. Markets did not replace State planning—they complemented it. Surpluses entered free markets while planned production continued. The coupling of plan and non-plan production with increased distribution channels seems to have been the effective strategy in Cuba. It is reminiscent of the "double-track" Chinese strategy (Weber, 2021), which by progressively implementing a new economic logic (markets) allows actors to learn know-hows and routines before it is scaled up. This avoids destructive sharp disruptions.

3.2.3. Prerequisites for this peculiar shift in metabolism and structure

As shown in table 1 and figures 6 and 7, the shock from reduced imports triggered a shift toward agroecology and a move away from sugar—partly out of necessity. Yet this transformation was neither automatic nor inevitable. It reflected long-term trends and Cuba's historical context–i.e., path dependence.

Two main conditions shaped this transition. First, preexisting agroecological initiatives and "*campesino*" know-how. Second, the socialist institutional base, which explains the initial society resilience: egalitarian values (figure 2), widespread education, centralized planning ("Acopio" in figure 5), absence of agro-industrial dominance ("Productive structures" in figure 5 to figure 7), and rural institutional support. In the late 1980s, agroecology already gained traction: the Cuban Association of Forestry and Agricultural Technicians registered as an NGO in 1987 to promote such practices (Brenner et al., 2014). This was the foundation of the model now widely used in the twenty-first century in Cuba. Urban agriculture also relied on preexisting accustomization of city dwellers to farming techniques through schooling and *campesino* family ties (Bayler, 2018, p. 28).

Likewise the previous experience of the 1970s' "consensual" management instated the administrative know-hows and precedents (although only partially efficient) that enabled the increased flexibility of the system to scale up during the Special Period.

It should be noted that the same path dependence dynamics occurs for institutional inheritances that *oppose* a degrowth shift or in the case of Cuba that restricted the possible adaptation strategies. For example, the unbalanced productive structure, implying imports dependence for a number of essential goods (machinery, vehicles, food, household equipment) and energy (figure 4); or the strong bureaucracy with its own goals and views on what the Special period policies should be.

3.3. Not a post-growth regime

The agrofood sector impulses macro changes but is also partly conditioned by national institutional features. The emerging regime is still growth-dependent, with sectoral post-growth dynamics.

3.3.1. Impeded accumulation and regulation through shortage and sufficiency

The RT framework can be leveraged to make sense of the agrofood sector trajectory. RT shows how sectoral dynamics both influence and are constrained by macro institutions (Boyer and Saillard, 2001). A sector can shape accumulation regimes by mainstreaming practices and values –like finance did in post-Fordism– but is also influenced by dominant macro structures.

In Cuba agriculture appears to be the driving force behind the material and institutional fundamental change in the global material footprint. Urban gardening and low-input farming introduced sufficiency practices. The partial shift from centralized planning toward a State-supervised emergence of grassroots methods, seems to be driven by agricultural change, through urban networks and farmers' markets. The black market is first and foremost an agricultural market, and it is the income from the resale of foodstuffs that provides access to certain specific resources during the special period.

But agriculture did not fully depart from productivism or the assisted rentier model. As shown in figure 7 and table 1, sugar production, transformation and export are lower but remained central. The State never renounced sugar; its decline stemmed from constraints, not intent, apart from the land diversification strategies. This is explained by its role in the accumulation regime, and and the State's resistance to reform. The single-party system and central State were non-negotiable institutions. This fundamental institutional environment thus preconditioned the extent and form of changes that could happen in the agrofood sector, and the subsequent sociometabolic transformation. This conditioning dynamic of the macro context takes tangible forms: political staff is present at every level, from companies to State planning system, effectively enforcing the official goals for the economy that the food sector has to fulfill. The prominence of biomass in the accumulation model partly explains the State's support for alternative farming–it was a strategy to integrate, not confront, bottom-up change (Bayler, 2018, p. 33).

Considering the full picture, we can explain how the agrofood transformations fit in the global institutional architecture (figure 8).

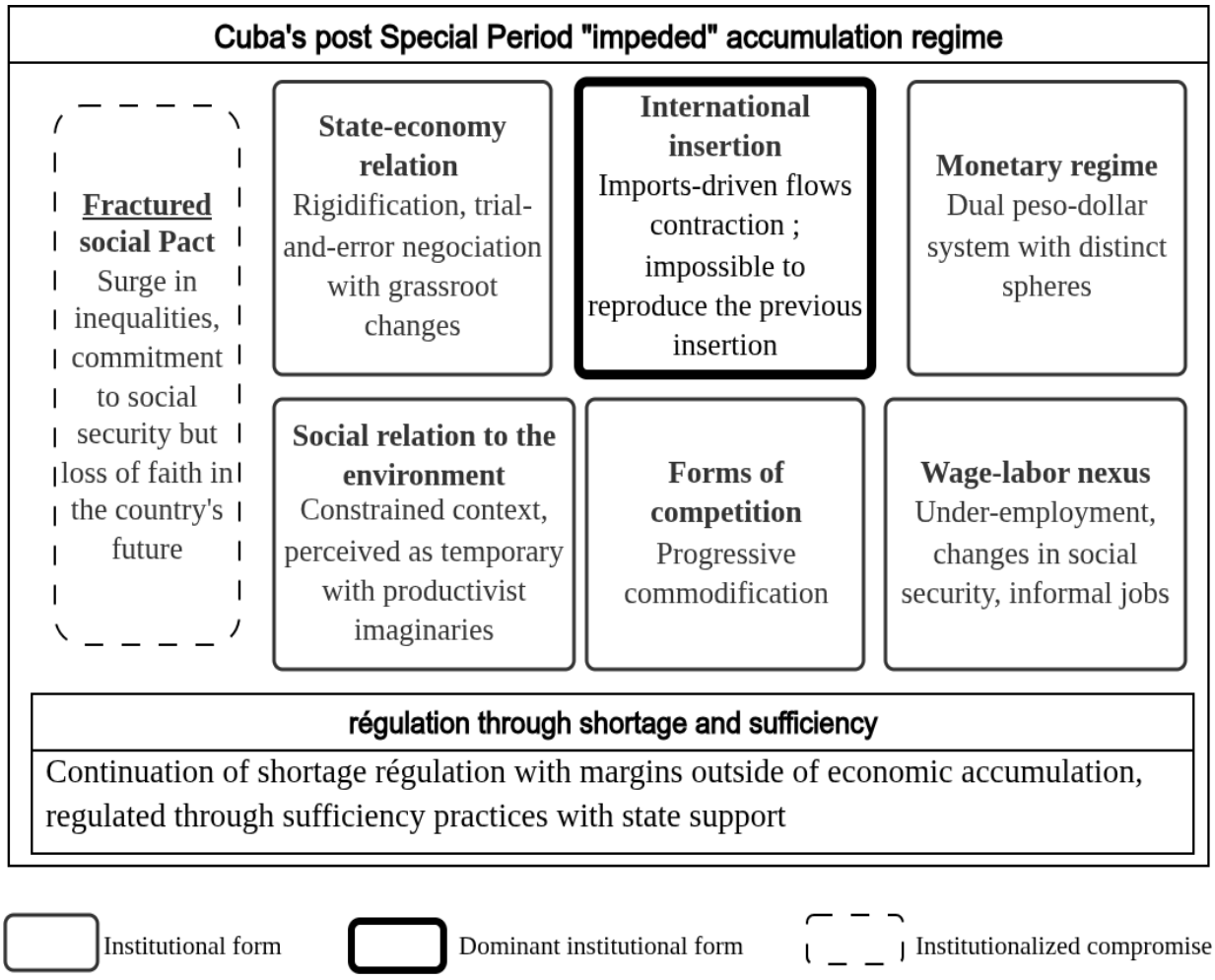


Figure 8: Institutional structure defining the accumulation regime in Cuba post Special Period.

The main institutional changes concern the mode of regulation and the social pact. The international insertion remains the dominant institutional form, signaling that the economic regime has not entirely departed from the previous model. Within the institutional forms, the defining traits describe a very different society.

The strategy was to maintain the existing accumulation regime, especially its form of international insertion. No serious assessment was made of this model's weaknesses (Habel, 2003, p. 19), even though the political rent it relied on no longer existed in the post-Soviet order. This continuity must be understood in light of the preservation of core socialist institutions, which were prioritized over the "social pact".

Nonetheless, the agrofood sector introduced changes in the mode of regulation. Sufficiency practices and communal or self-provisioning formed a distinct regulation, coexisting with persistent shortages. These practices supported an "impeded" accumulation regime: one aiming to reproduce past rents, while tolerating sectors of society moving in different directions. These margins—related to food, health, and non accumulation-based provisioning—emerged from grassroots initiatives and were later State-institutionalized. They created a degree of popular autonomy in the face of the State's failure to uphold the social pact, which once linked socialism to economic growth.

3.3.2. The democracy hypothesis strengthened?

This is where an important case can be made for the democracy defining criterion in the degrowth literature: does the Cuban case advocates for "green dictatorship"? To the contrary, it highlights the absence of democratic planning as a barrier to broader transformation in degrowth contexts. This opens a space to discuss democratic planning alternatives and in doing so, to translate a degrowth normative hypothesis into a positive reasoning. The reasoning is the following. Because the Party–State core was untouchable (figure 2), the changes seen in figures 5 to 7 reflect a tension between State preservation and grassroots adaptation amid systemic disorganization. This strategy reduced the possibilities of emerging from the crisis by strengthening social cohesion. The situation is for example weakening the government's own position: "*The changes that have taken place have not brought about the necessary political changes, thus reinforcing the contradictions between the aspirations of the social subjects and a contested State centralization (the failure to take into account the proposals and demands of the workers formulated in the production assemblies is a constant remark in the surveys carried out by academics)*" (Habel, 2003, p. 20, translated).

Another example could be that agroecological practices or low-impact farming were seen by many Cubans as temporary and imposed. Productivist ideals still dominated representations of the future. The motives of sustainability or environmental impact were not explicit in everyday practices (Nelson et al., 2009). On the other hand, there is no hostility to agroecological practices. But they did not adhere to a new paradigm prior to the shift, nor were they themselves prime drivers in agroecological expansion, and consider the ongoing situation as temporary.

A "third way," granting people more decision-making power, could have enabled a deeper, needs-based reconfiguration–less dependent on sugar. But this contradicted the single-party system. Far from constituting an example of institutional transformation capable of managing the decrease in flows, the way in which the Cuban State reformed itself may be where changes resented by the population originate from. While inequality was contained thanks to socialist legacies, the system grew rigid, and the planning–population link deteriorated.

Proposals for adaptive and democratic planning systems suggested by Durand et al.(2024) would have had the opposite characteristics, which also highlights that planning in itself is not the heart of the debate, but rather the specific form it takes.

4. Discussion and contributions

4.1. Key takeaways

Based on Special Period Cuba, what institutional features might be linked to degrowth? Sections 3.2.1– 3.2.3 explored present and absent criteria of degrowth. Table 2 summarizes key degrowth criteria from the literature and applies them to Special Period Cuba. Cuba illustrates institutional dynamics linked to systemic throughput reduction—partly voluntary in a context of planning and basic needs satisfaction inherited from socialism. However, we do not observe radical political change before the reduction, nor democratic or justice-oriented processes. Only a full combination of these criteria would constitute degrowth. Judging endogenously, crucially absent were voluntary change (e.g., prior shifts in dominant values or desires) and a democratic context. This brings support to their presence in degrowth definitions.

The three observed criteria combined to create dynamics where social outcomes partly decoupled from biophysical consumption. The underlying institutional context featured a shift of the planning system towards greater polycentricity (Ostrom, 2005) and a balance between decentralization and centralization. New socioeconomic logics spread through a "double-track" strategy combining planned and non-planned production, or official and non-official. Markets existed but differed from Global North norms: non-hegemonic and with few intermediaries.

The first metabolism reconfiguration was the decline of productivist, exports-oriented sectors relative to domestic uses (starting from a very unbalanced economy). They were downscaled, not greened or made more efficient. End uses were first shaped by biophysical limits, "by disaster". Then the productive structure had to follow, with the caveat that sugar production still benefited from strong political support.

The second reconfiguration was the rise of the informal sphere. I interpret this mainly as a reaction to rigidities in the centrally planned system and the enforcement of productivist norms in some sectors. As shown in figures 6 and 7, this informal push entailed both decommodification (self-provisioning) and commodification (black market). It is therefore difficult to uniformly explain this increase in informal activities.

Finally, RT shows how historical context and institutions shape degrowth trajectories. For example, the appearance of urban agriculture was shown to require particular prerequisites and may not be associated to any theoretical degrowing society.

Definitive extrapolation from one case is not possible. Nevertheless, Cuba may suggest dynamics linked to designed material reduction *by design*. RT distinguishes (at least) three levels of analysis from general to particular : the mode of production (e.g. capitalism), the accumulation regime (e.g. fordism), the mode of regulation (e.g. regulation through shortage). We gained insights on all, shaping patterns of what degrowth regimes could entail. Here is how we can summarize it. At the mode of production level, basic needs provisioning logic would likely replace profit. Activities would be largely decoupled from corporate interest. As is posited in degrowth studies, social control over the broad economic direction and goal as well as other levels of planning, should be democratic. Specifically, control of economic goals could not rest with a single class, capitalist or bureaucratic. The accumulation—or de-accumulation—regimes could mix centralized and decentralized economic planning. Markets and planning may coexist in a form of "double-track", where the later progressively takes over the former in most activities, but not all. Planning would coordinate diverse production and distribution forms and include adaptive feedback loops (Dryzek, 2019) which were clearly missing in Cuba. This feedback would concern emerging alternatives but also unanticipated social or economic dynamics associated to rapid reconfigurations. This could range from company committees to municipal or provincial levels acting as basis of bottom-up processes. Beyond top-down *vs* bottom-up, the key notion is *polycentricity*. The modes of regulation vary for a given de-accumulation regime, even more for one mode of production. It cannot be definitively stated what is or is not degrowth-compatible. Nevertheless we observed that practices and values of sufficiency, if self-emerged, support de-accumulation processes. Here takeaways also go against some presuppositions in the degrowth literature. Regardless of whether they are desirable or not, the Cuban case showed that the speed of changes alone can generate social suffering. The "impeded regime" synthesized the clash between hegemonic values of accumulation *versus* the constrained biophysical context and showed that well-being may decrease simply because of the mismatch between hegemonic values and sufficient or sober objective yet unintentional lifestyles.

Table 2: Degrowth defining criteria and how the Special Period Cuba case study relates to them

Degrowth definition criterion	Example references	Cuba	Short explanation
Whole economy throughput reduction	Schneider, Kallis, and Martinez-Alier (2010, 1; Hickel 2020, 1; Kallis et al. 2018, 1)	Yes	This is the main feature of the Special Period
In a planned, voluntary way	Hickel (2020, 1; Kallis et al. 2018, 1)	≈	The downscaling is unwanted, but long-lasting and with planning features
Provoked by radical economic and political	(D'Alisa, Demaria, and Kallis 2014; Kallis et al.	No	Main cause is the downfall of the USSR and US embargo

change	2018)		
In a democratic way	(Koch, Buch-Hansen, and Fritz 2017; Schmelzer, Vetter, and Vansintjan 2022)	No	The authoritarian nature of the regime is progressively reinforced
Aimed towards social justice	Hickel (2020, 1; D'Alisa, Demaria, and Kallis 2014)	No	The primary goal of government reforms is to access foreign currency, and secondarily to preserve if possible the egalitarian social compromise
That increases wellbeing	Hickel (2020, 1; Kallis et al. 2018, 1)	No	idem
That satisfies basic needs	Hickel (2020, 4; Koch, Buch-Hansen, and Fritz 2017)	≈	Cuban socialist institutions like rationing or social security provide a legacy of satisfying basic needs

4.2. Contributions

4.2.1. Novel contributions.

The study first brings new elements to RT. It applied RT for the first time to post-growth topics using a real case. This opens the door to further work on post-accumulation regimes as a different class of regimes, where RT can be leveraged to generalize case studies and delineate the structure of such economies (Durand and Légé, 2013). Second, the RT framework shows potential for degrowth research, to better understand what degrowth entails in terms of social relationships, and especially in how contradictory tendencies may find coherence. Such contradictory tendencies are often downplayed in the degrowth literature but inevitable in any system (Durand and Légé, 2013). RT also clarifies the levels of analysis, from the most abstract (mode of production) to the most empirical (mode of regulation). This should help distinguish between necessary and non-necessary degrowth policies, as is currently not the case (Fitzpatrick et al., 2022). Third, the analysis integrated socioeconomic dimensions into metabolism representations, to show quantitative production shifts and how they relate to qualitative institutional structure changes.

This general framework yielded new takeaways for degrowth reflections: the potential need for international links or coordination between degrowing economies; the inspiration from real-existing mechanisms like double track planning, or the role of State to back up and institutionalize emerging changes. The latter is also linked to the relevance of planning mechanisms and a certain degree of centralization within polycentricity observed in Cuba, and which was recently highlighted as not enough envisioned within the degrowth literature by Durand et al. (2024).

This debate on degrowth also has broader implications for sustainability in general, as mentioned in the introduction. We analyzed what socio-economic structures can be linked to a lighter metabolism, so previous remarks on degrowth hold for this purpose. It also implies that radical societal change should be incorporated in models to explore faster and safer transition options. Several calls have already been made in this direction (Hickel et al., 2021; Keyßer and Lenzen, 2021; van Vuuren et al., 2018).

4.2.2. Corroborating contributions.

Several findings corroborate existing hypotheses in the degrowth literature, bringing them empirical support. Namely, the democratic dimension, the impossibility of forcing the transition without prior desire for it, the prime role of grassroots impetus and adaptation, the centrality of basic needs. The latter is especially relevant in countering profit logics that could oppose metabolism reconfigurations –though in systems where absent, partially reintroducing them can help, as was the case in agriculture in Cuba.

4.3. Limits

The visualization relied heavily on literature, especially prior fieldwork. It also depended on our research question and the related institutional features deemed worth representing. It thus may not apply to all cases, nor was it the only possible approach in the case at hand. Other metrics could have been included, e.g. land or working time, as is the case in the Musiasem approach (Giampietro and Mayumi, 2000). Further extrapolation would thus require comparative case studies, for which RT is a fruitful framework.

The Special Period case is so rich that many questions remain untouched, and could relate to how the social security system behaved without growth, specifically how health was maintained (Borowy, 2013), what became of investment at the aggregate level, how the situation led to a reconfiguration in gender roles, lessons for unequal exchange studies, how we can better understand the potential rigidities in work transformation, etc. Future studies could focus on other metrics such as energy—especially in relation with endemic blackouts and/or catastrophic events as typhoons—or how the Cuban metabolism evolved across all material flows.

5. Conclusion

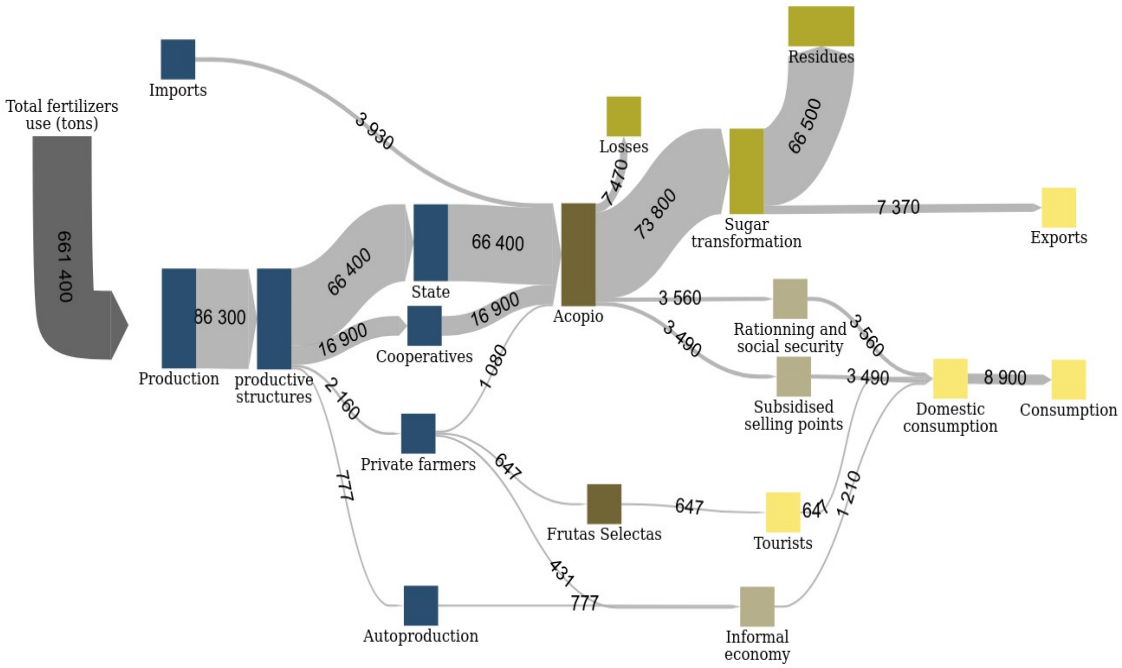
Partially covering degrowth, the Cuban showed how an economy was (in part) re-purposed through polycentric planning, basic needs provisioning, and double-track mechanisms. We also explained why the system was not fully growth-independent and what missing elements account for this. The absence of democracy supported one of degrowth's main hypotheses. Yet degrowth research should also attend to several aspects highlighted here. First is the issue of social conflict inherent in degrowth. Second is how international relations may enable or block degrowth institutionalization. Third is the level of

abstraction at which degrowth policies apply—mode of production, (de)accumulation regime, or mode of regulation—and their related necessity or contingency.

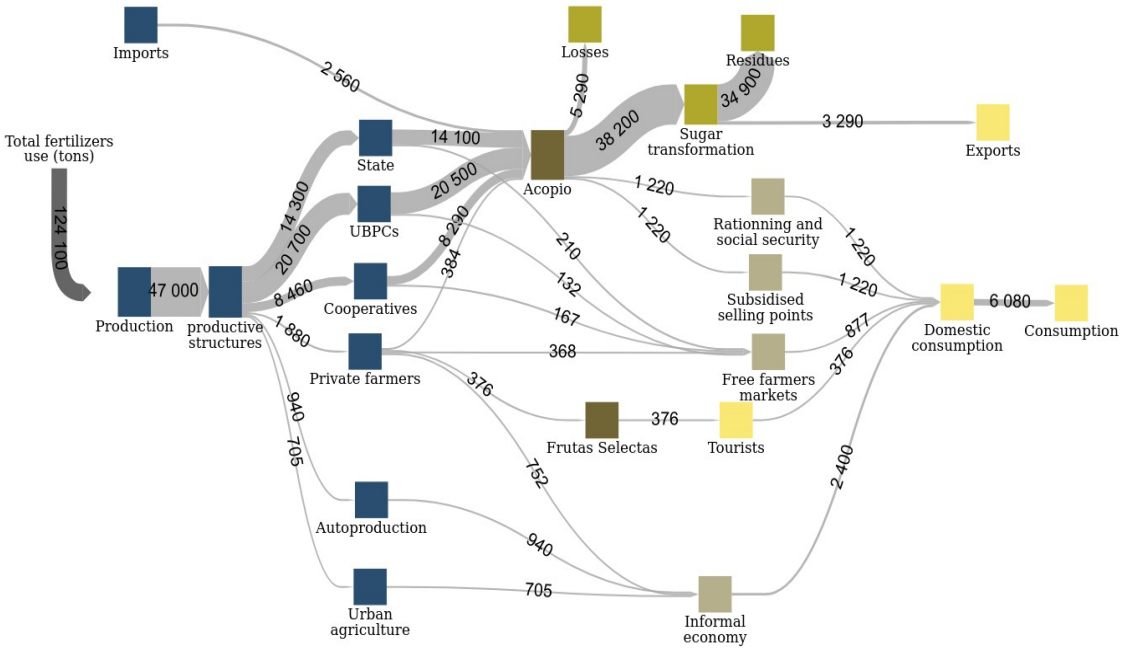
New cases are needed to diversify observed and unobserved degrowth criteria. Further work can leverage the RT–metabolism framework to analyze other macro cases or the political economy of sub-parts of degrowth—for example, dismantling an activity, or scaling up public provisioning and linking it to global throughput reduction.

Appendix

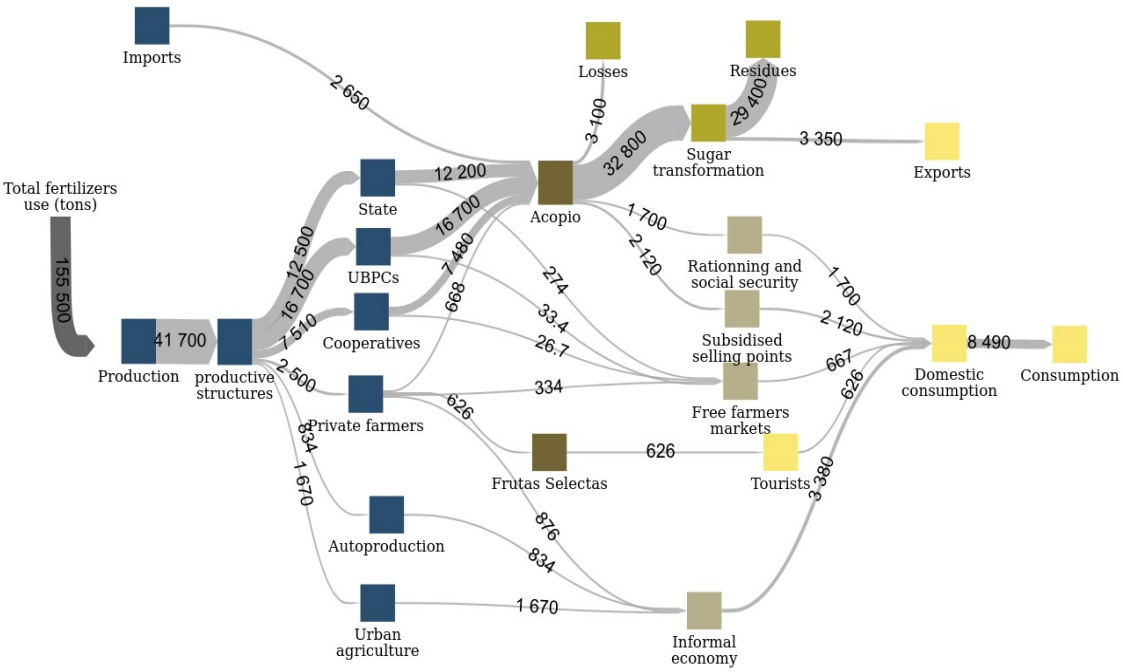
1. Side-by-side comparison of biomass metabolisms



Biomass metabolism in 1989, kt fresh weight



Biomass metabolism in 1994 , kt fresh weight



Biomass metabolism in 1999 , kt fresh weight

2. Sub-components of the “Vegetables, other” series

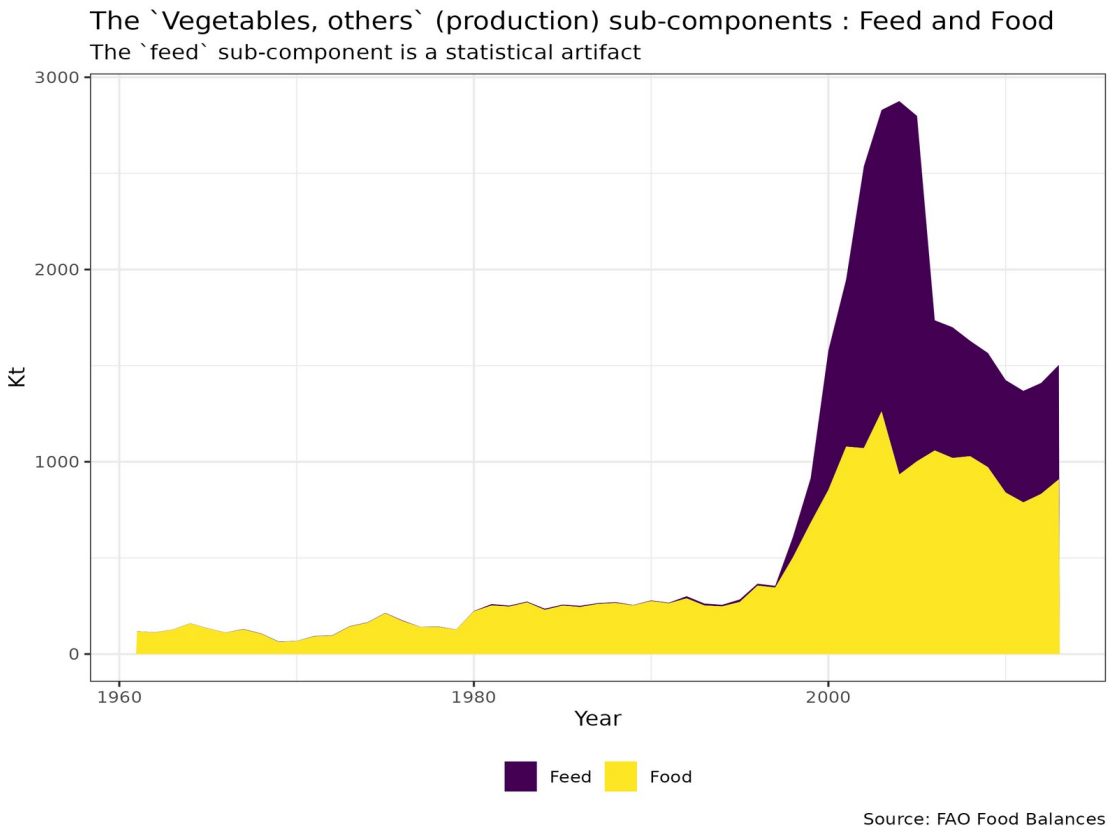


Figure 9: The “feed” sub-component is the source of the surge, while the “food” sub-component behaves plausibly. Upon solicitation of the FAO, it was confirmed that only the “food” sub-component had to be used. This is what I applied.

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