

# Chapter 9

## Agrarian Metabolism and Socio-ecological Transitions to Agroecology Landscapes



Enric Tello and Manuel González de Molina

### 9.1 From Land Reform and Agrarian Capitalism to Energy Accounting of Agriculture

After studying law and economics at the University of Barcelona, Joan Martínez Alier started doing research in agricultural economics at St Antony's College in Oxford from 1966 to 1973, publishing *La estabilidad del latifundismo* and an upgraded English version of this same book, which dismissed the hypothesis of the supposedly backward 'feudal' character of Andalusia's large estates (Martínez Alier, 1968, 1971). His work also rejected the 'primitive' character of the labourers' resistance and rebellions claimed by some Marxists (Hobsbawm, 1959) and the Spanish Communist Party, which was then leading the resistance to Franco's dictatorship. He then went to Cuba and Perú to study, with Verena Stolcke, how surplus was extracted from those who worked the land either through hired labour or different agrarian systems of tenancy, treating these peasant economies in ways that went beyond orthodox neoclassical economics (Martínez Alier, 1977, 1978a). This research connected him with the views of the Russian Narodnik Aleksandr V. Chayanov (1966 [1925]; Martínez Alier, 1978b), then being revived by Theodor Shanin (1971, 1973, 1974) and others. His contributions had a broad impact on international debates on the agrarian question of the time (Kay, 1974, 1977), together with the books and articles on Spanish agriculture of his friend José Manuel Naredo (1971, 1978a, b, and Naredo et al., 1975).

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The two friends also collaborated in editing the political journal *Cuadernos de Ruedo Ibérico*, issued in Paris (1965–1979) with a critical stance towards the policies adopted by the Spanish left opposition parties at the end of the Francoist dictatorship (Naredo & Martínez Alier, 1976) and making an early connection with the awakening of environmentalism, which also started in Spain with the opposition to nuclear plants and big new dams (Naredo, 1973, 1981; Gaviria et al., 1978). This drew their attention to the energy question (Naredo & Martínez Alier, 1979; Martínez Alier, 1980, 1982, 2019: 213–220). Martínez Alier had already made energy accounts of food baskets in his studies of agrarian economics and went deeper into the subject after reading Roy Rappaport's *Pigs for the Ancestors* (1968). Together with Pablo Campos, José Manuel Naredo calculated the first energy balance for Spanish agriculture and its declining rates of return with the Green Revolution, one of the world's first examples of agricultural EROI calculation (Campos & Naredo, 1980; Naredo & Campos, 1980).

The two authors also started reviving the work on energy economics of Sergei Podolinsky, another socialist-oriented Ukrainian Narodnik, pointing out the failed opportunity to start an ecosocialist current a century earlier than it took place, owing to Marx's doubts and death, and Engels' final refusal (Martínez Alier & Naredo, 1982; Martínez Alier, 1995). Podolinsky's attempt was praised by Valdimir Vernadsky (2007: 212) in the Soviet Union in 1924, when such an event entailed great risk, like the trial and death of Chayanov in the 1930s. However, some recent ecological Marxists still try to dismiss his forerunner essay (Foster & Burkett, 2008). They are wrong, and Martínez Alier and Naredo were right in putting the finger on the sore of the Marxist tradition. The only 'obituary' that deserves to be explained is why, since 1883, so many Marxists ignored Marx's ecological and energy-related inklings, with only a very few exceptions (Sacristán, 1992; Tello, 2016).

## 9.2 Growing Up as Historians in the Debates over the Agrarian Question in the 1970s

The influence of Martínez Alier on the authors of this chapter began during the last years of the Franco dictatorship and at the beginning of the disappointing transition to the current Spanish parliamentary monarchy. At that time, most of the intellectuals who were linked to the Communist Party denied that a bourgeois revolution had taken place in Spain and considered the *latifundio* and *minifundio* to be 'feudal remnants' of an agrarian system that was not yet fully capitalist. According to Martínez Alier and Naredo, the idea that the *latifundios* were largely inefficient could no longer be sustained. The large estates were among the protagonists of the process of 'agrarian modernization' that was then already taking place. The need for agrarian reform could no longer be argued on the grounds of promoting economic development. The only valid reason in its favour was ethical, not economic.

Industrial agriculture, which was then being championed by left and right political parties alike, had profound ecological impacts, which Naredo and Martínez Alier were pioneers in denouncing. However, the productivism of this ‘agricultural modernization’ still inspired the Agrarian Reform Law approved by the Andalusian Parliament in 1984, when Spain’s imminent entry into the European Common Market diverted political concerns towards production surpluses rather than more intensive agriculture (Naredo & González de Molina, 2002).

This agrarian debate framed our training as historians when we graduated and began our doctoral theses (González de Molina, 2020a, b; Tello, 2020). At this time, a vigorous labour movement had re-emerged in Andalusia in pursuit of land reform from below, making the works of Martínez Alier and Naredo even more relevant in political and historiographical terms. Manuel González de Molina got in touch with them for the first time in a conference on agrarian reform in the University of Granada, initiating a relationship that has lasted until today. That collaboration between academics and members of the *Sindicato de Obreros de Campo* (SOC) continued throughout the 1980s, and the ecological component gained more and more momentum. It gave rise to an original socioenvironmental synthesis around the so-called Andalusian Pact for Nature, a movement with a peasant base that progressively assumed clear environmentalist approaches (Herrera et al., 2010).

Joan Martínez Alier participated in the seminars then organized in Córdoba, Baeza (Jaén) and La Rábida (Huelva) by Manuel González de Molina and Eduardo Sevilla Guzmán, seminars linked to the first peasant experiences with organic agriculture in the context of the SOC cooperatives (González de Molina & Guzmán, 2017). That was the true birth of agroecology in Spain, opening a fruitful debate on the role of the peasantry in social and political change. From these experiences and debates emerged a proposal for an ecological neo-populism, which was actively spread by Martínez Alier (1985a, b, 1987b, 1988, and Flores Galindo & Martínez Alier, 1988). Eduardo Sevilla Guzmán and Manuel González de Molina coordinated a book on *Ecología, Campesinado e Historia* (1993), including a chapter by Víctor Toledo (1993), emphasizing the ecological rationality of peasant production that laid the socioecological foundations for neo-populist proposal from within agroecology.

Enric Tello met Joan Martínez Alier for the first time in 1979 at a *Seminar on the energy crisis in a capitalist society* at the University of Barcelona, organized by the Catalan Antinuclear Committee, of which he was member. It opened with a lecture by Martínez Alier on *Energy and agrarian economy* (Martínez Alier, 1980) and closed with another by the Marxist Manuel Sacristán (1980) on *Why does the environmentalist movement lack economists?* Martínez Alier was then writing his well-known book *Ecological Economics* (1987a), first issued in Catalan (Martínez Alier, 1984). In 1980, Sacristán founded the first ecosocialist journal in the world, called *Mientras Tanto* (the second, *Capitalism Nature Socialism*, only appeared in 1992; Tello, 2003, 2016). Enric Tello joined its editorial board in 1982, the agrarian historian Ramon Garrabou already being a member. At that time this red, green and violet journal paid attention to the birth of the German Greens and published the

first European Ecosocialist Manifesto (Antunes et al., 1990). However, Sacristan died in 1985. When Víctor Toledo, Manuel González de Molina and others sent a co-authored article to *Ministros Tanto* claiming the political importance of new peasant organizations like *Via Campesina* as a transformational subject of social change, a group of neo-orthodox Marxists on the editorial board imposed an aggressive veto against publishing it. It was the beginning of the end of this journal's interest in views from political ecology, which were spread instead by the journal *Ecología Política*, founded by Martínez Alier in 1991.

In 1992, with Miguel Altieri, Stephan Gliessman and Víctor Toledo, Martínez Alier also participated in the first agroecology course taught in Spain in Baeza and has continued participating in it and in the doctorate and master's courses at La Rábida ever since. Besides explaining the new field of ecological economics (Martínez Alier, 1993), he advanced from the 'ecological neo-Narodism' (Martínez Alier, 1985a, b) towards what later became the *Environmentalism of the poor* (Martínez Alier, 2002). He also began proposing the development of a socioecological history (Martínez Alier, 1990, 1993). All these approaches encouraged new research on Andalusian peasant conflicts in the nineteenth century (Cobo et al., 1992). Environmental history emerged in Spain at the beginning of the 1990s in the recently founded Spanish Society for Agrarian History (SEHA). After some debates on forest history and common pool resources (González de Molina, 2000), Ramón Garrabou organized the first Spanish environmental history encounter in Girona, which led to the first special issue published on the subject edited by González de Molina and Martínez Alier (1993).

### 9.3 From Agrarian History to the Environmental History of Agroecosystems

The First Spanish Environmental History Conference was held in Andújar (Jaen) in 1999, with an opening lecture by Rolf Peter Sieferle. The best contributions were published in a volume edited by Martínez Alier and González de Molina (2011). The Second Spanish Environmental History Conference took place in Huesca in 2001 with more than 200 registered participants and an opening lecture by John McNeill, leading to another book (Sabio & Iriarte, 2003). Martínez Alier also encouraged the creation of the European Society for Environmental History (ESEH) and put Manuel González de Molina in touch with the Social Ecology Institute (SEC) in Vienna. In 1999, he presented a first paper there considering the use of environmental variables to explain the contemporary history of Spanish agriculture, later published in a collective book in Spanish and in *Ecological Economics* (González de Molina, 2001, 2002). Through these and other channels he was in touch with approaches from social metabolism (Ayres & Simonis, 1994; Opschoor, 1997; Fischer-Kowalski, 1998; Fischer-Kowalski & Hüttler, 1998; Carpintero, 2005). At the same time, Enric Tello started calculating the energy and water

balances of the social metabolism of Barcelona city by participating in several environmental campaigns (Tello, 2002, 2005; Puig et al., 2003; Roca et al., 2006).

Enric Tello and Manuel González de Molina met each other in the SEHA, founded in 1990. In 1994, they both attended the first meeting to bring together agronomists, soil scientists and biologists with agrarian historians, launched at the SEHA by Ramon Garrabou and José Manuel Naredo, which gave rise to a first book on soil fertility management (Garrabou & Naredo, 1996). The experience was very successful and led to other meetings held in 1996 devoted to soil water uses and balances, giving rise to a second book (Garrabou & Naredo, 1999). A last meeting held in 1999 focused on agricultural landscapes (Tello, 1999). It also produced a third book (Garrabou & Naredo, 2008), which took a step forward due to the methodology proposed by José Manuel Naredo to address it. That is, using the energy and material flow accounting of agricultural metabolism to study cultural landscapes as a territorial ‘imprint’ of the biophysical flows driven by different types of farming throughout history. This meant recalculating the energy balances of Spanish agriculture made in the early 1980s. But 20 years later, material and energy flow accounting (MEFA) had been developed in ecological economics. Martínez Alier and others had created the ICTA at the Autonomous University of Barcelona in 1997 (Martínez Alier, 2019: 61–64) and were joined by Mario Giampietro in 2007. His articles and books on the energy analysis of agroecosystems became key references on the subject (Giampietro & Pimentel, 1991; Giampietro et al., 1994; Giampietro, 1997, 2004). To apply a socio-metabolic approach to agroecosystems required novel MEFA accountancies.

Fascinated by the analytical potential of this biophysical analysis for agroecology and environmental history, Manuel González de Molina began to collaborate with Víctor Toledo at the UNAM Institute of Ecology in Morelia (Mexico). Their first joint contribution on social metabolism was presented at the International Symposium on Environmental History held in Xalapa (Mexico) in 2001, in which Joan Martínez Alier also participated (Toledo & González de Molina, 2007). The agroecologists Gloria Guzmán and Manuel González de Molina calculated and published their first historical energy balances of an Andalusian farm system in the same issue of *Historia Agraria* in which Ramon Garrabou, Enric Tello, Xavier Cussó and the agronomist José Ramón Olarieta had done this in a Catalan case study, also published in *Ecological Economics* (González de Molina & Guzmán, 2006; Guzmán & González de Molina, 2006; Cussó et al., 2006a, b; Tello et al., 2006). Both teams started applying the same type of energy accounting that had already been used by Naredo and Campos (1980), but that first attempt led to a methodological disagreement. Pablo Campos criticised Enric Tello on the grounds that the Catalan energy balance failed to treat the internal provision of services, like animal traction and manure obtained reusing internal biomass flows, as a cost. Pablo Campos and Javier López-Linage did so in working out the energy balances of the Spanish wood pasture or *dehesa* and other case studies (Campos & López-Linage, 1997; Campos & Casado, 2004; López-Linage, 2007). The Catalan research group adopted it, but the Andalusian researchers did not.

In a debate between the two teams, together with Naredo, Campos and López-Linage, held in Madrid in 2007, González de Molina criticized the fact that Campos' calculation of agricultural energy balances only focused on the farmers' viewpoint from the perspective of environmental economics. Tello replied that the importance of these internal reuses of biomass and of internal services provided by the multiple uses of livestock were a hallmark of traditional organic agriculture compared to the linear industrial ways of farming. Gloria Guzmán pointed out that farming biomass reuses played very important roles from an agroecology standpoint other than provisioning internal economic services to farmers. These conceptual and methodological difficulties made apparent, once again, the lack of a socio-metabolic energy-flow analysis conducted from an agroecological point of view. Clearly, new types of concepts, models and indicators were required to study agrarian metabolism from a long-term historical perspective.

## 9.4 Advances in the Study of Agrarian Metabolism as a Tool for the New Agroecological Transition

During the First World Conference on Environmental History, held in Copenhagen in 2009, the North American environmental historian Geoff Cunfer and Fridolin Krausmann from the Vienna SEC proposed to join with Manuel González de Molina, Enric Tello and Stefania Gallini to draw up a proposal to study the historical socioecological transitions of agricultural systems using socio-metabolic calculations, to be submitted for a Partnership Grant to the Social Sciences and Humanities Research Council of Canada. The research project *Sustainable Farm Systems: Long-term Socioecological Metabolism of Western Agriculture* (SFS) was approved in 2012 and allowed the assembly, up to 2018, of a network of teams in Canada (Saskatchewan and Edward Prince Island), Austria (Vienna), Spain (Seville and Barcelona), Colombia (Bogotá and Cali) and Cuba, later enlarged with collaborators in the United States, the Czech Republic and Costa Rica. To date, 82 energy balances of past and present farm systems have been calculated using a novel agricultural energy analysis. Many of them were published in a special issue of *Regional Environmental Change* in 2018 (Gingrich et al., 2018a, b), while others are still being published. This is the largest dataset of energy and soil nutrient balances of farm systems to use the same methods of calculation from a long-term historical perspective thus far. It is considered the most circular of all the current different methods used in the field by the latest review article on the subject (Hercher-Pasteur et al., 2020).

So as to provide comparable results, compiling these case studies required solving the above-mentioned debate on calculating energy. To consider the important role of farmers' internal reuses of biomass, Enric Tello and other SFS researchers started to draw increasingly circular flow diagrams of the socio-metabolic interaction among the fund components of agroecosystems (i.e., the different land uses of

farmland, the livestock, the farming community and the rest of society) during the sojourn of Geoff Cunfer as visiting researcher to the University of Barcelona in 2012. This led them to realize that using a single EROI indicator of the energy performance of a complex agroecosystem became a straitjacket for this circular approach. The conceptual barrier started to be overcome in 2013 while Enric Tello was a visiting researcher in the Vienna SEC, working with Fridolin Krausmann and Simone Gingrich. The energy return to all inputs invested, including internal biomass reuses, was called Final EROI. It was then decomposed into an Internal Final EROI and an External Final EROI (the latter being the only agricultural EROI formerly calculated in the literature). This multi-EROI analytical approach avoided the internal flows of agroecosystems driven by farmers remaining into a black box (Tello et al., 2015). The three agricultural EROIs are related, so that the Final EROI equals the product of IFEROI and EFEROI divided by their sum. This equation allows the performance of optimality analyses to be contrasted with the actual historical evolution of these energy returns (Tello et al., 2016).

Two main general results using this novel multi-EROI energy analysis have been obtained thus far for North America and Europe. First, throughout the socioecological transition from past organic to industrial agriculture, farm systems have fallen into an energy trap of much lower EFEROI values due to the sharp increase in the consumption of fossil-based external inputs above the growth in final produce. This confirms the diagnosis made by the first agricultural energy balances half a century ago (Leach, 1976; Pimentel & Pimentel, 1979), despite the recent small EFEROI increases observed in the last two decades (Pellegrini & Fernández, 2018). Second, although the changes in IFEROI and FEROI values have been less significant (Gingrich et al., 2018b), the relative maintenance of their values over time conceals deep structural changes in the composition and integration of agroecosystems among live funds, mainly driven by the dietary transition (which increased the proportion of cereals diverted towards animal feed at the expense of crop by-products and of poor natural pastures being increasingly wasted), and by the forest transition (which reduced forestry in the Global North, lowering the more energy-dense component in the output obtained with lower energy inputs). Behind the energy trap of industrial farming lies a loss in the complexity and circularity of agroecosystems and the integration of their fund-flow patterns.

Gloria Guzmán, Manuel González de Molina and their Andalusian colleagues in the Agroecosystem History Lab agreed on this novel ecological economic multi-EROI, which was adopted by the whole SFS research project, but stressed the agro-ecological importance of the total photosynthetic Net Primary Production of agroecosystems, and the part of it that remains unharvested and feeds the food chains of non-colonized species either above ground in the landscape or below ground in the soil biota. This perspective linking agrarian metabolism to farm-associated biodiversity and related ecosystem services was incorporated by the Spanish SFS teams, but has not yet been adopted by others, leading to other types of EROI and other methodological advances being made by the Andalusian team (Aguilera et al., 2015). Gloria Guzmán and Manuel González de Molina took the

lead in developing this agroecology energy analysis (Guzmán et al., 2014, 2018; Soto et al., 2016; Guzmán & González de Molina, 2015, 2017; González de Molina, 2020b), relying on the conceptual approach to agrarian metabolism put forward by González de Molina and Victor Toledo (2011, 2014). This led to two different but compatible versions of multi-EROI energy analysis: agroecological and bioeconomic.

At the same time, the SFS Catalan team took over Ramon Margalef's hypothesis on the capacity of a mosaic pattern of complex agricultural landscapes to host biodiversity. The whole energy turnover of an agroecosystem, starting from the solar Net Primary Production (NPP) up to the decomposition of food chains of soils, were calculated using graph modelling. This graph avoids double-counting energy flows by replacing the addition of their energy content with the proportions of each flow, which are split into two at each node, one looping inside the agroecosystem, the other either going outside it or coming into it. This new analytical approach allowed an Energy-Landscape Integrated Analysis (ELIA) using as indicators the share of NPP that remain temporarily stored within the agroecosystem; the Shannon index of how evenly NPP energy flows circulate across all possible paths of the graph, taken as an indicator of the information complexity of the agroecosystem (Sherwin & Prat-i-Fornells, 2019); and the land cover diversity of the landscape, which corresponds to this pattern of energy flows, calculated by means of another Shannon index through GIS in digital maps (Marull et al., 2016, 2019a; Font et al., 2020).

These three ELIA indicators (energy storage, information complexity and landscape heterogeneity) can be assessed in each cell of a grid applied through GIS to the digital map of any landscape to evaluate across gradients how heterogeneous land covers are (L), how complex the energy fund-flow pattern is (I) and how dissipative the socio-metabolic energy flows become (E). The latter E indicator means monitoring what Martínez Alier and Naredo (1982) called the Podolinsky Principle in agricultural landscapes. The former two (I and L) build on the proposition of Ramon Margalef (2006 [1973]) that a differentiated pattern in the spatial distribution of external energy flows turns ecosystems into agroecosystems, giving rise to complex landscape mosaics with heterogeneous land covers which offer differentiated habitats to non-domesticated species (Loreau et al., 2010; Jackson et al., 2011). Applied to Mediterranean agroecosystems, and tested with actual data on biodiversity locations, the ELIA model has proved to have a good predictive capacity (Marull et al., 2019b). Further ongoing improvements proposed by Manuel González de Molina and Gloria Guzmán aim at differentiating the agroecological importance of the diverse paths taken by matter-energy flows across the graph.

Another development of our agrarian metabolism approach is SAFRA, a prospective nonlinear programming model used to forecast the different landscape configurations that will arise from optimizing the uses of land, labour and other resources from a set of site-specific biophysical restrictions and capacities of agroecosystems, according to different social aims, including the diet to be provided (Padró et al., 2019, 2020). The model is devised to improve deliberative processes of agroecology transitions towards more sustainable agri-food systems and territories (González de Molina et al., 2019; González de Molina & Lopez-Garcia, 2021).

Other advances have started calculating social and gender inequalities from a socio-metabolic point of view. Manuel González de Molina and Víctor Toledo (2011, 2014) began this task in their books, and some SFS researchers have followed this approach (Gizicki-Neundlinger et al., 2017; Gizicki-Neundlinger & Güldner, 2017; Marco et al., 2020a, b). Finally, the socio-metabolic approach developed so far has started to combine environmental, social and economic dimensions in the recent book *The Social Metabolism of Spanish Agriculture* (González de Molina et al., 2020). There is a long way to go in making socio-metabolic calculations from these social and gender perspectives – an avenue for young scholars to advance.

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