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COMMENTARY

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Commentary: New histories of the Indian Green Revolution

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The Green Revolution continues to be a touchstone in debates on food production. Accounts generally cite "high-yielding" dwarf wheat and rice spreading through Asia and particularly India, resulting in lives saved, agriculture modernised, and under-utilised workers moved off farms. This Commentary examines the forces that popularised this version of events and then reviews a significant new body of writing, comprising five major works by historians. The new work provides a fundamental rethinking of many key aspects of the revolution, including the motivations behind it, the merits of the agricultural science in India that it displaced, whether the new seeds actually led to increased food production, and how concepts of desirable plants changed.

KEYWORDS
agriculture, biotechnology, crop breeding, Green Revolution, India

1 | INTRODUCTION

The Green Revolution has few serious competitors as the most discussed chapter in agricultural history. One quickly loses count of the books, articles, proposals, speeches, op-eds, documentaries, and press releases that cite the legend of input-intensive, short-stalked ("dwarf" or "semi-dwarf") wheat and rice varieties spreading through parts of Asia 50 years ago. The tale resonates particularly well because it has a hero (the dynamic, no-nonsense, Nobel Peace Prize-winning breeder Norman Borlaug), a villain of sorts (unstoppable population growth), a happy ending (a "billion lives" supposedly saved, and many peasants freed from the drudgery of farming), and an optimistic moral about scientific innovation solving world problems.

A critical literature has also grown around the Green Revolution, particularly as it unfolded in India. Numerous writers over the years have raised concerns over issues of social equity and capitalist penetration of peasant economies in critiques varying in scholarly rigour. But the past few years have brought a remarkable flush of new, archive-based, and well documented research on the Green Revolution, mostly from early-career historians of science. This Commentary synthesises five books/dissertations in history or hybrid science/history that collectively provide an interesting and iconoclastic new understanding of the Indian Green Revolution – including what was driving it, how it reflected and affected key ideas about agriculture, how it shaped food production, and even how important scientific innovation really was.

The door to the new body of work was opened in 2010 by historian Nick Cullather's *The hungry world: America's Cold War battle against poverty in Asia*. That was followed by Saha (2012) *State policy, agricultural research and transformation of Indian agriculture with reference to basic food crops, 1947–1975*; Subramanian (2015) *Revisiting the Green Revolution: Irrigation and food production in 20th century India*; Siegel (2018) *Hungry nation: Food, famine, and the making of modern India* (based on a 2014 dissertation); and Baranski (2015a) *The Wide Adaptation of Green Revolution Wheat*. Also worth mention, although not specifically focused on India, is Olsson (2017) *Agrarian crossings: Reformers and the Remaking of the US and Mexican Countryside* (based on a 2013 dissertation).[1] Since the interpretation emerging from this group

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of historians is so starkly at odds with the conventional legend of the Green Revolution, we need first to consider that legend and its genesis.

2 | LEGEND MAKING

The deployment of short-stalked varieties of wheat in northern India in late 1967 was not the obvious stuff of legend. Such varieties had been growing in Mexico for a decade and had generated few headlines. Developed by the Rockefeller Foundation's Mexican Agricultural Program (MAP), the seeds had helped turn Mexico into a wheat exporter while lining the pockets of commercial farmers (Cullather, 2010, p. 68). None of this attracted the level of attention that the crops would attract in India, where several forces converged to generate the legend.

One such force was the modern environmental movement, which was ramping up and developing a fascination with overpopulation in India: notably, in 1968, Paul Ehrlich's best-selling *The population bomb* announced that India could not be saved from falling over a Malthusian cliff. Another force was Borlaug, who used his 1970 Nobel acceptance speech to proclaim a victory in the perpetual war between "two opposing forces, the scientific power of food production and the biologic power of human reproduction" (Borlaug, 1970). Borlaug would spend the rest of his long life burnishing what some have called the Green Revolution brand (Sumberg et al., 2012). US government leaders also had reasons to publicise the adoption of American-backed agricultural technologies in Asia. Lyndon Johnson posed in a field of dwarf rice in the Philippines and declared that the war on hunger was the only war he sought to escalate; when US AID's William Gaud coined the name "Green Revolution" he explicitly contrasted it to the red revolution of the Soviets.

More recently, agri-biotechnology interests have zealously promoted the Green Revolution legend to help frame genetically modified (GM) crops as key to feeding the global South (Glover, 2010; Stone, 2002). Thus a Monsanto chief recounts visiting an aging Borlaug, who teared up because he had lived through the Green Revolution but would not see the Gene Revolution (Gillam, 2009). The early 2000s have also brought calls for a new "Green Revolution for Africa" (Schurman, 2018), reliably larded with allusions to averted famines and depictions of hunger as an apolitical technological problem (Cullather, 2010, pp. 264–265).

All of this has kept alive the seed-centric narrative in which Borlaug bred innovative high-yielding dwarf wheat that was adopted after he brushed aside the backward-looking traditionalists in the Indian establishment. Joined by dwarf rice and powered by chemical fertilisers and expanded irrigation, these seeds are supposed to have revolutionised agriculture in the developing world and averted famines – especially in overpopulated India, which had been kept alive in the 1960s only by shiploads of American wheat.

As noted, this narrative has been the subject of challenge and critique. Important early concerns were raised about the wheat programme being focused on India's largest and wealthiest farms. Saha (2012) unpacks the work of the influential Planning Commission (PC), the members of which were not the tradition-bound Luddites of the legend; they were trying simultaneously to create a functional state (after centuries of colonial rule followed by the horrors of partition), to avoid becoming a prized Cold War client, and to shape the country's agricultural destiny. India was short on manufactured inputs and long on rural labour and organic manures, and the PC sensibly wanted to capitalise on these resources. They were not opposed to chemical fertilisers, but regarded them as highly expensive both to the state and to the farmer. Concentrated fertiliser use also had ecological problems: they cited research indicating that chemicals should only be used in combination with bulky organic manures to preserve tilth – a position that many in India today wish had been followed (Anand, 2011). Borlaug branded these views as obstacles to innovation and progress, and as the legend of averted famines took on the appearance of fact, Borlaug's opponents were largely relegated to the dustbin of agricultural history.

Critiques of socio-economic impacts also began early, with development scholars documenting a widening gap between rich and poor farmers as soon as the new seeds spread (Frankel, 1971; Glaeser, 1987; Ladejinsky, 1969; Pearse, 1980). The inequity of the country's wealthiest farmers enjoying a state-subsidised windfall (as they had in Mexico before), while many poor farmers could not afford inputs for the new seeds, is omitted in popular retellings of the Revolution, but the problem was eventually acknowledged even by the Rockefeller Foundation itself (Conway, 1997). Vandana Shiva's *The violence of the Green Revolution* (1991) offered a scathing analysis of the agro-ecology of the new crops and a wide-ranging critique of the revolution's underlying political projects; although widely read, many scientists have seen Shiva's attacks more as activism than scholarship, and even historians have distanced themselves from it (Siegel, 2018, p. 186). John Perkins' *Geopolitics and the Green Revolution* (1997) gained more scholarly traction with its analysis of the political underpinnings of the agricultural changes. His recasting of the Green Revolution as a political Cold War project, in contrast

to Borlaug's apolitical vision of agricultural science versus population, invited a re-framing that encouraged the new body of research.

3 | NEW HISTORIES

Although not focused on India, Olsson's book provides fascinating context by showing how the MAP was inspired by Rockefeller programmes for poor tenant cotton farmers in the US South. Those programmes had promoted small farmer independence from the market, judicious use of on-farm resources, and increased production of subsistence crops to foster independence from creditors (Olsson, 2017, p. 106; also Harwood, 2009) – an ironic start for a programme that would send input-intensive seeds to well off Indian commercial farmers. But as Cullather shows, the MAP's focus quickly evolved from helping Mexican smallholders to using Mexico as a laboratory for experiments in agricultural development – particularly for Asia, which was believed to suffer from population/food disparities (Cullather, 2010, p. 44). Mexico actually had no food/population gap; it had rural poverty but was exporting cattle, vegetables, fruit, and coffee (Cullather, 2010, pp. 43–44). Still, the MAP fixated on raising crop yields, which was "a solution in search of a problem" (Cullather, 2010, p. 45). Borlaug may have seen his work as part of a primal clash between world hunger and agro-industrial science, but he was actually an agent in a set of interlocked political and economic projects driven by then-fashionable development theories. Many mid-century thinkers saw population growth as simply adding superfluous bodies to the countryside beyond the fixed numbers of hands needed to plough, plant, and harvest. Moving excess rural labour to work in urban factories was actually expected to raise agricultural output (Cullather, 2010, p. 147).

But these theories of agricultural growth were being up-ended just as the Green Revolution crops were being deployed. In 1964, economist Theodore Schultz's *Transforming traditional agriculture* held that peasant farmers were efficient, although in need of external industrial inputs to raise production. In 1965, economist Ester Boserup's *The conditions of agricultural growth* showed that rural societies put people to work on crowded landscapes through labour-based intensification *without* recourse to external technologies: fallows shortened, added labour went into fertilising, tilling and weeding, and output per unit area and per unit time rose. This was even happening in India: indeed that is where Boserup's initial insights came from (Boserup, 1999, p. 20). Green Revolution enthusiasts have generally ignored this research and dismissed those who "romanticise" small-scale farms (Borlaug & Dowswell, 1995, p. 123), but there is nothing romantic about the rigorous empirical research on Boserupian intensification (e.g., Boserup, 1970; Netting, 1993; Stone, 2001; Turner & Ali, 1996). The agricultural development projects based on mid-century theories were propelled by Cold War anxieties about rural poverty breeding communist insurgency. This was particularly true in India, with its enormous size, its history of colonial-era famines, and its Communist influences (Saha, 2012). But a more important cause of rural distress in India was Prime Minister Nehru's insistence on developing heavy industry at the expense of agriculture. The US government encouraged the urban industrial priority (Cullather, 2010, p. 230), with the US farm lobby blocking any "real effort to boost the agricultural output of one of the United States' major surplus importers" (Siegel, 2018). The PL-480 Food Aid programme became central to India's food policy and the primary vehicle for dumping US surplus. Like Perkins, Cullather sees American grain shipments not as having remedied India's 1960s grain shortages, but rather causing them by discouraging investment in food production (Cullather, 2010, p. 144).

But while India's economic policies undermined wheat production, they encouraged the growing of non-food cash crops. Where Borlaug saw a simple Malthusian inability to grow enough food, millions of acres were being switched from rice to jute production. Indian agriculture even enjoyed an export boom in the mid-1960s; most of the jute went to the US, where it made seats for the tractors that produced the grain, and also the sacks that held the grain being shipped to India (Cullather, 2010, p. 181).

But, as Siegel shows, by the mid-1960s India was ready for a rethinking of the proper economic arrangements of post-colonial life: land reform had petered out, efforts to control market players had stalled, and the Nehruvian ideology was fraying. Then in 1965 fate intervened in the form of a drought, which leads Cullather to an insightful dive into the timing, meaning, and consequences of famine and famine narratives. He writes that the "capacity to declare an emergency confers substantial power, and for that reason states, politicians, and factions vie for the authority to predict, define, and explain famine," and our historical memory of the Green Revolution emerged from just this struggle (Cullather, 2010, p. 206). US President Lyndon Johnson, who was struggling to get Congress to pay for stepped-up food aid, led the charge in establishing a narrative of famine – to the surprise of the Indian agriculture minister, who called it scaremongering (Cullather, 2010, p. 223). In 1966, US headlines announced famine in the Indian state of Bihar, although British journalists who knew India better were circumspect (Dunn, 1966). But when the drought stretched into a second year, Malthusian alarms went off and

pundits warned that Indians could soon be feeding on each other. But "[i]nconveniently, Indian officials declared the famine a sham," and reporters searched in vain for starving peasants (Cullather, 2010, p. 223). Even in Bihar, demographic analyses would later find scant evidence of excess mortality (Cullather, 2010, p. 223; Maharatna, 1992, pp. 353–354). To be sure, it was a hard year for the Bihari poor – Prime Minister Gandhi had found it expedient to invoke India's "famine codes" – but the problem had not been population outpacing food production, but rather farm work drying up when commercial crops like jute and sugarcane failed. But these events of 1966–1967 would morph from an overblown story of starvation in Bihar into a harrowing fantasy of India having passed a Malthusian point of no return.

The drought provided what Borlaug called the "opportune moment"; it started just as Borlaug and his Indian collaborator MS Swaminathan began multiplying the Mexican seeds in northern India, and conveniently ended just before the new seeds' first big year. Then, with good rains on top of ample irrigation, the 1967–1968 winter season brought a bumper wheat crop. The Mexican seeds claimed credit, yet "yields of nearly every crop – cotton, tea, jute – were at record levels," even in countries like China where no Green Revolution grains had been planted (Cullather, 2010, p. 233).

All of the new histories delve into not only what happened in the test plots and farmers' fields, but also into how the Green Revolution changed thinking about agricultural research and innovation. Baranski examines how basic philosophies of crop improvement became enmeshed in politics within the breeding world. She focuses on the concept of "wide adaptation" (WA); that is, plant breeding that purportedly maximises yields across a wide range of growing conditions, rather than for specific macro environments. Breeders on Indian agricultural stations tout the trait as ideal, but most ecologists consider it dubious, as did many Indian agricultural scientists in the 1960s (Baranski, 2015a). The rise of this philosophy of crop improvement is less a story of agronomic superiority than of personality, politics, and publicity.

Wide adaptation was the conceptual handiwork of Borlaug, whose trademark "shuttle breeding" – planting winter crops in the northern Mexican desert and selecting seeds to plant as summer crops in the central mountains – selected for the WA trait of photoperiod insensitivity. WA also selected for fertiliser responsiveness, for reasons that grew out of the particular historical moment. In the 1940s, few food crops were heavily fertilised and breeders were not selecting for response to intensive chemical fertilising, but with war-time nitrogen-fixing munitions plants proliferating, nitrogen fertiliser was bound to become more plentiful (Baranski, 2015a, p. 12). Borlaug began to breed wheats for the growing class of capitalist farmers in Mexico who could afford chemical fertiliser and who enjoyed state-subsidised irrigation. That these seeds were "wide adapted" was true only in a deceptive sense: they could thrive in a wide range of soils and latitudes, but only with ample fertiliser and irrigation.

But India was not Mexico; it was a much larger country with enormous variation in agricultural economy and ecology, being torn by major tensions between capitalist and communist, industrial/urban, agricultural/rural, and among differing regional interests. Providing seeds and subsidised resources for wealthy commercial irrigated wheat growers in the North would be a nettlesome problem (Saha, 2012, pp. 98–99). Borlaug's team therefore claimed that the Mexican seeds would thrive even with low fertility and limited irrigation: they "*respond* to but do not necessarily *require* irrigation and extremely heavy fertilization" (emphasis original) (Baranski, 2015a, p. 104). They also proposed that varieties developed in ideal environments could perform well in marginal environments, but not vice versa (Baranski, 2015a, p. 138). Baranski shows the claim to be a fiction (as does Subramanian, citing different data): Borlaug's flagship varieties out-yielded indigenous tall wheats only when at least 80 kg/ha of fertiliser was applied (Baranski, 2015a, p. 179; 2015b; Subramanian, 2015, p. 55). Indian breeders had developed their own dwarf wheat varieties but did not release them for this reason, preferring to improve local varieties adapted to actual availability of inputs. However, following the Green Revolution's claims of averted famine, WA became the dominant breeding strategy in India.

The new histories also raise troubling questions about the claims of averted starvation. Subramanian in particular upends thinking not only on the causes of rising wheat yields, but whether overall food production rose at all during the Green Revolution. His study sidesteps the usual (deceptive) comparison between the drought years (1966–1967) and 1968, instead comparing pre-drought, Green Revolution, and post-revolution periods. To do this he combines his own analysis with production figures that have been hiding in plain sight in a historical blind spot (perhaps because they are so discordant with the Green Revolution legend). Following Sarma and Gandhi (1990, p. 17), Subramanian (2015, p. 44) finds that the real breakthroughs in Indian food-grain production began around 1950, while the mid-1960s actually marked the start of "a decade and a half of *relative slowdown* in the growth of production and yields of foodgrains" (emphasis added) (Subramanian, 2015, p. 9). Wheat yields did indeed rise after 1967 (Table 1), but wheat was only India's third crop behind sorghum and far behind rice. For the paramount food crop of rice, the growth rates in both yields and area planted actually slowed during the Green Revolution years; thus overall rice production, which had been growing at 3.5% annually, slowed to a 1.9% growth rate, a 46% drop (Table 1). Total food-grain production, which had been growing at 2.8% annually, slowed to a 1.9% growth rate during the Green Revolution years, a 32% drop.

Moreover part of the price for the shift to wheat was paid by the pulses that were vital to both nutrition (due to their high protein) and agricultural ecology (as nitrogen fixers) (Saha, 2013, p. 300): pulse yields had been growing at 1.2% annually but declined during the Green Revolution (Subramanian, 2015, p. 43). (Other analyses have made different but consistent points; for instance Byerlee [(1992), p. 478] lumps production by decade, finding that yields for rice, coarse grains, and all cereals rose more slowly in the 1960s than before or after.)

Since these data contradict the legend of India's Green Revolution years so conspicuously, let us augment Subramanian's periodised breakdown with a graphic analysis of long-term patterns in Indian food production. Figure 1 shows a strongly linear trend in growth of food-grain production during the last half of the twentieth century. Note in particular that after the

TABLE 1 Adjusted annual growth rates for wheat, rice, and food grains before, during, and after the Green Revolution years

Period	Rice (%)	Wheat (%)	Total food grains (%)
Area			
1950–1965	1.3	2.7	1.4
1968–1976	0.7	3.2	0.4
1976–1984	0.2	1.9	0.2
Yield			
1950–1965	2.2	1.3	1.4
1968–1976	1.2	2.2	1.5
1976–1984	1.8	3.7	2.3
Production			
1950–1965	3.5	4.0	2.8
1968–1976	1.9	5.5	1.9
1976–1984	2.0	5.7	2.5

Source: From Subramanian (2015, p. 45), based on Sarma and Gandhi (1990)

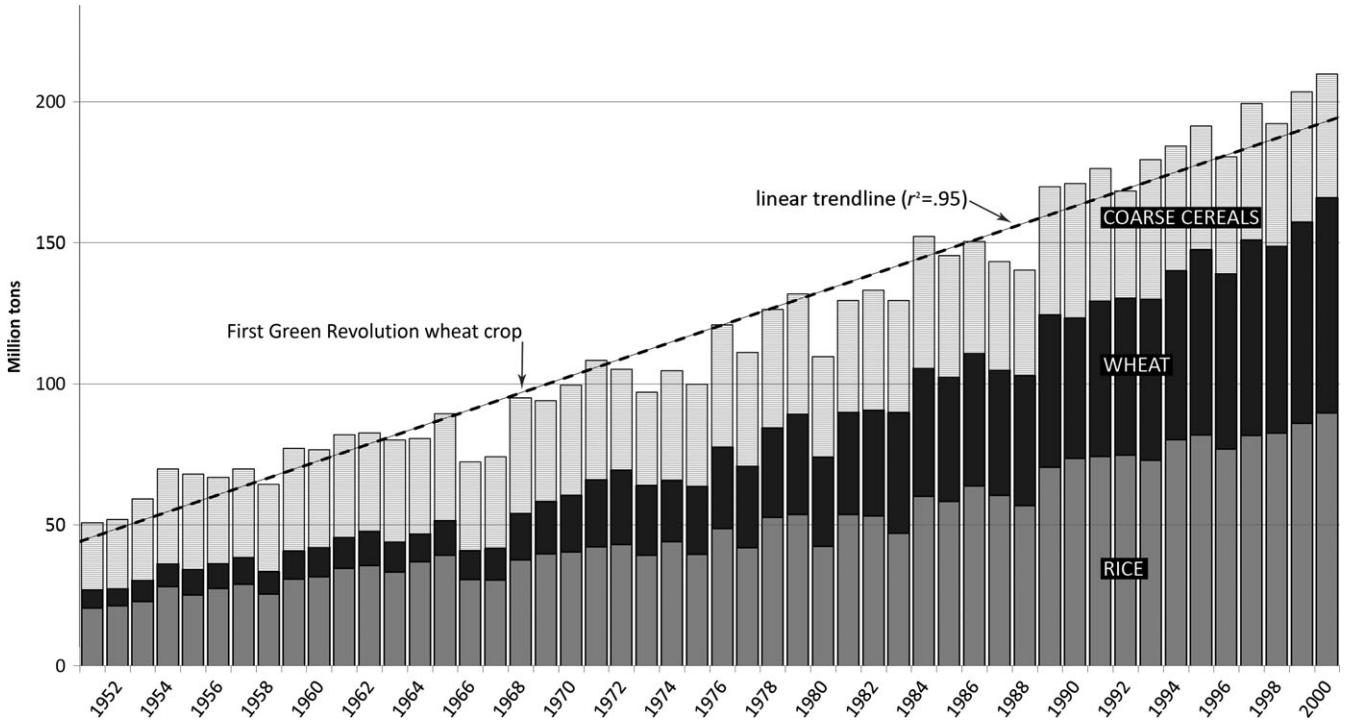

FIGURE 1 Trends in production of the major categories of food crops in India during the last half of the twentieth century. Data are from the India Department of Agriculture & Co-operation at http://agricoop.nic.in and http://eands.dacnet.nic.in/latest_20011.htm.

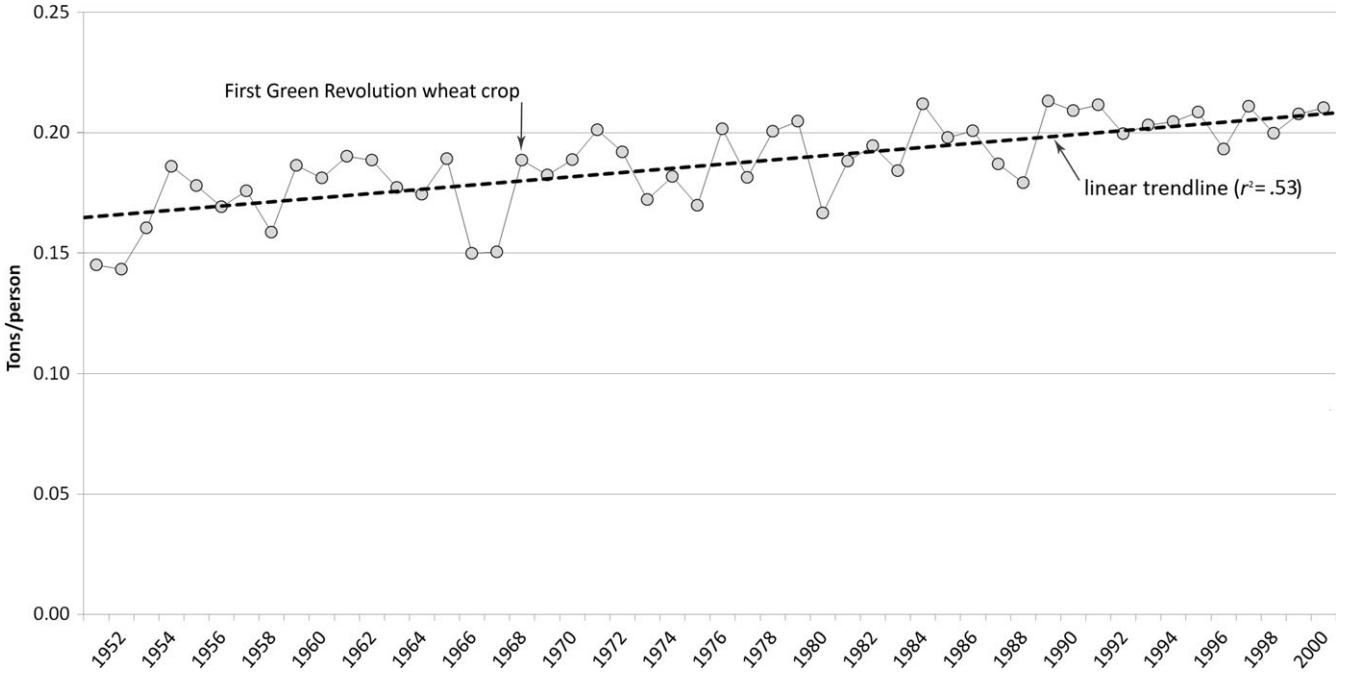

FIGURE 2 Trend in India's total food-grain production divided by population. The data sources are the same as for Figure 1.

production slump during the two-year drought just before the Green Revolution, production returned to its earlier trend with no sign of "revolution."

But since the Indian Green Revolution is always framed in Neomalthusian terms, we have to look at growth of production vis-à-vis population. Figure 2 shows that, while the first harvest of Mexican wheat did coincide with the end of the "opportune" two-year drought, it did not mark a change in the steady linear rise in per capita food-grain production India has enjoyed since the mid-century.

Subramanian goes even further, making a case that the primary cause of the wheat boom was not Borlaug's seeds or even the subsidised fertiliser, but the massive surge in private tube well construction (2015, pp. 9, 182–233). Again the accidents of timing proved crucial. In 1965, a World Bank mission had just convinced India to adopt an irrigation policy based on private tube wells; the goal was not so much to produce more food – more irrigation from dams or collective/public tube wells probably would have been better at that – but to promote "high-input, high-output agriculture" (Subramanian, 2015, pp. 192, 210–211). Propelled by government loans, subsidies, and rural electrification (in part to run the tube-well pumps), by 1969 there were almost a quarter of a million private tube wells in operation and the state had spent Rs 5.5 billion on minor irrigation and rural electrification (Subramanian, 2015, pp. 192–193). Farmer adoption of the new seeds and increased fertiliser hinged on whether or not they had tube wells (Subramanian, 2015, p. 200).

Tube wells were also key to rice production, which boomed in the mid-1970s as tube wells proliferated on rice farms. The wells not only provided more water but freed farmers from the monsoon cycle (Subramanian, 2015, p. 37). As with wheat, the role of the dwarf rice seeds has been overstated.

Subramanian marvels that the Green Revolution's fans and critics alike have agreed on a "seed-centric narrative," even if they took opposite positions on the seeds' impacts (2015, p. 38). His analysis negates the seed narrative as well as the fetishising of agri-scientific innovation in general: irrigation after all is an ancient agricultural practice, and the spread of tube wells was not prompted by any breakthrough in technology but by a change in state policy (Subramanian, 2015, p. 12).

4 | TAKE-AWAYS

The legend of the Green Revolution in India has always been about more than wheat imports and short-stalked grains. It is about Malthusianism, with post-war India supposedly proving the dangers of population growth outpacing food production. It is also about the Neo-Malthusian conviction that technological innovation is our only hope, capable of saving a billion lives when conditions are right. Scholars may have destabilised some elements of the legend, and activists may have

scorned it entirely, but beneficiaries of the legend have bolstered it and kept it alive and well in our historical imagination. The new histories discussed here provide a serious scholarly rethinking. Historically detailed and carefully documented, sometimes agreeing and sometimes complementing each other, these works constitute a coherent reinterpretation that knocks out virtually all of the pillars of the earlier legend. Wheat imports resulted not from Malthusian imbalance but from policy decisions, and they were as much a cause of underproduction as a remedy. The legendary wheat-field triumphs came from financial incentives, irrigation, and the return of the rains, and they came at the expense of more important food crops. Long-term growth trends in food production and food production per capita did not change, although the Green Revolution years, when separated out, actually marked a slowdown.

The legend is also about India waking up to bold new ways of thinking about crop breeding, but the new research shows that Indian agricultural scientists were already developing technologies according to philosophies that made as much sense as that with which they were replaced during the Green Revolution.

The rethinking of what happened in India in the late 1960s is timely indeed. Today the world's largest charity is pouring money into a new Green Revolution for Africa and into public relations on the wonders of agricultural technologies. As Cullather points out at the end of his book, promotion of a new revolution is heavily dependent on invoking the Neo-Malthusian legend of the old one as a pure technological triumph. One wonders if the new wave of historical scholarship will make a dent in a reawakening of these debates today.

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ENDNOTE

[1] My focus on this set of books by historians is not intended to diminish the importance of shorter recent writing such as Patel (2013).

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