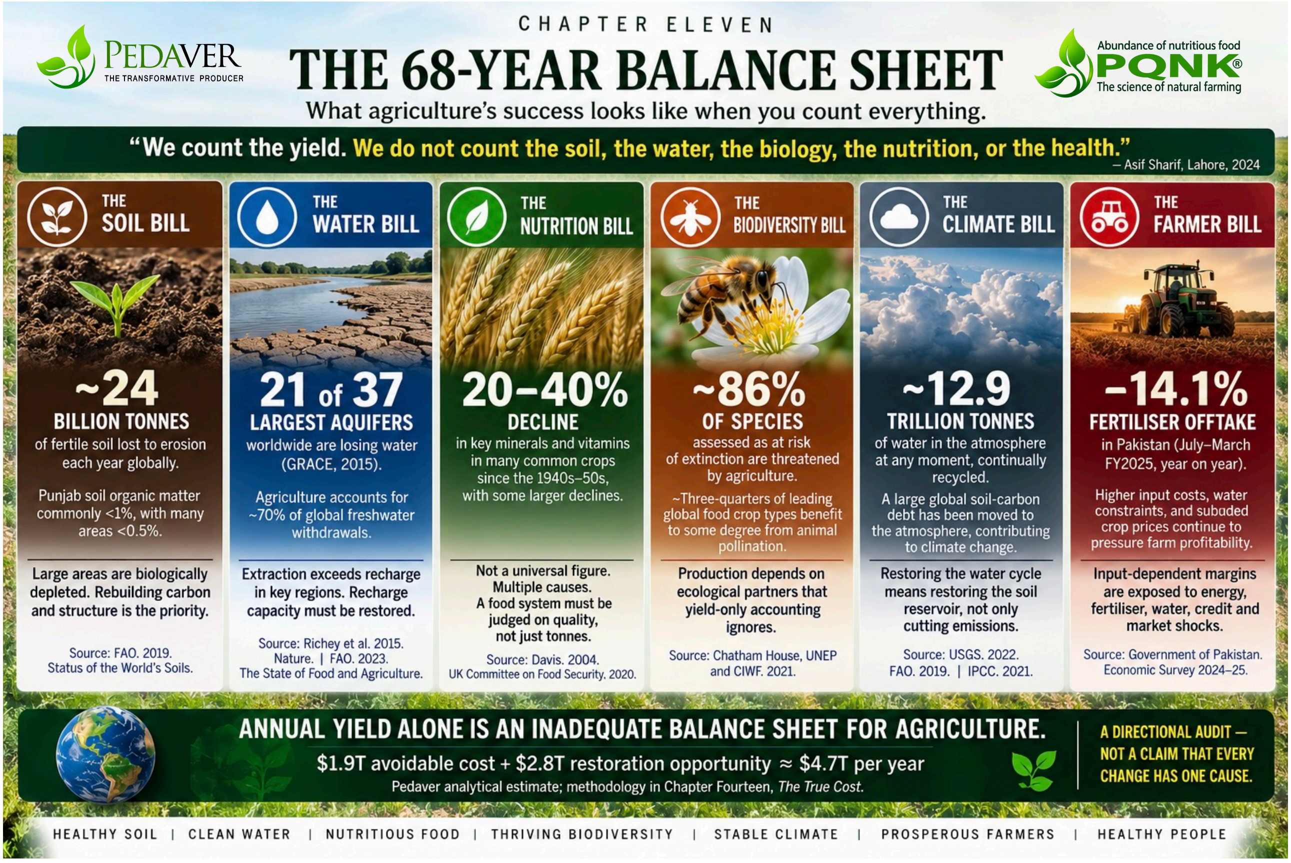
CHAPTER ELEVEN

The 68-Year Experiment



1958 to the Present, Measuring the Quantified Catastrophe

"We do not have a food production problem. We have a food production accounting problem. We count the yield and call it success. We do not count the soil, the water, the biology, the nutrition, or the health. If we counted everything, we would have stopped decades ago."
Asif Sharif, Lahore, 2024

The year 1958 is used in this book as the opening benchmark of a 68-year agricultural experiment, the period in which the industrial production package moved from earlier development into rapid global expansion. Agricultural soils were already affected by centuries of tillage, grazing, erosion, salinity and nutrient depletion. What changed in the decades that followed was the scale and intensity of intervention. Mechanisation, soluble fertilisers, pesticides, large irrigation systems, standardised high-yielding varieties, credit and extension increasingly operated together as a production architecture. The central question of this chapter is therefore not whether agriculture before 1958 was pristine. It was not. The question is what happened to soil, water, biodiversity, nutrition and farmer economics as industrial correction became the dominant response to agricultural limitations.

The history of that package also predates 1958. Superphosphate fertiliser was commercialised in the nineteenth century, while industrial synthetic ammonia became possible through the Haber-Bosch process in the early twentieth century. Tractors, pesticides and irrigation engineering likewise developed over different timelines. By the

1960s, however, these technologies were converging with Green Revolution breeding and public policy at unprecedented scale. The result was a major increase in cereal production, but also a 68-year period in which the ecological and economic costs of input-intensive production became measurable within a single human lifetime. This chapter presents that accounting.

WHAT ‘SUCCESS’ LOOKS LIKE WHEN YOU COUNT EVERYTHING

The standard account of the last 68 years of agriculture is a story of triumph. Global food production has more than tripled since 1960. Famines that once threatened entire regions have been averted. The Green Revolution’s high-yield varieties fed populations that conventional wisdom said could not be fed. Agricultural technology has advanced from the ox-drawn plow to GPS-guided precision machinery, from open-pollinated seeds to genome-edited varieties, from flood furrows to satellite-managed drip systems. By every measure that the agricultural establishment has chosen to count, the last 68 years are a success story.

The question that this chapter asks is: what happens to that story when you count everything? Not just the yield, but the soil that produced it. Not just the food, but the nutrition it contains. Not just the harvest, but the water used to grow it and the water table that supplied that water. Not just the production, but the biological capital consumed to achieve it. Not just the tonnage, but the health outcomes of the people who ate it. When all of these are counted, the story of the last 68 years is not a triumph. It is a profoundly incomplete accounting of agricultural success.

The Green Revolution increased yield per acre dramatically in many crops and regions. But yield alone does not tell us what happened to soil organic matter, groundwater reserves, biological diversity, nutrient density, input dependence or farmer margins. The purpose of this chapter is to place those other accounts beside the yield account. A production system cannot be judged by what leaves the field while ignoring what the field loses in producing it.

THE SOIL BILL: WHAT WAS MINED AND NEVER REPAID

The most fundamental resource in agricultural production is the soil itself. Seed, water, fertiliser, pesticide and machinery all operate through a soil environment whose productive capacity depends not only on mineral content but also on organic matter, aggregation, pore structure, roots and biological activity. Repeated intensive tillage, prolonged bare-soil exposure, erosion, compaction and some chemical-management regimes can draw down these functions faster than they are rebuilt. The result is not simply 'less soil'. It is soil that receives water differently, cycles nutrients differently, supports roots differently and becomes progressively more dependent on external correction.

The global accounting is serious. International assessments report that a substantial share of the world's soils is degraded, while roughly 24 billion tonnes of fertile soil are lost to erosion each year. Long-term land use and cultivation have also created a very large global soil-carbon debt. These figures should not be read as the product of one technology or one decade. They represent the cumulative consequence of land conversion and management over long periods, with intensive modern agriculture accelerating degradation where disturbance, erosion and carbon removal exceed biological rebuilding.

Pakistan's Punjab shows the same direction of change. Contemporary surveys commonly report very low soil organic matter in intensively cultivated soils, frequently below one percent and in some locations below half a percent. Historical values were not uniform across the arid and alluvial landscape, so this chapter does not impose a single 1950s baseline on the whole province. The defensible conclusion is nevertheless clear: repeated cultivation, residue removal, bare soil, limited organic return and intensive input-based management have left large areas biologically depleted. PQNK addresses that deficit through permanent cover, retained roots, minimum disturbance and the rebuilding of soil biological function.

THE WATER BILL: AQUIFERS DRAWN DOWN, CYCLES BROKEN

Water is the second major account in the 68-year experiment. Agriculture accounts for roughly seventy percent of global freshwater withdrawals. In many important agricultural regions, groundwater is being extracted faster than it is replenished. Satellite observations have made the scale of groundwater stress increasingly visible. The important distinction is between using renewable water within the rate at which the landscape can receive and recycle it, and mining stored groundwater because the soil-water system can no longer meet crop demand efficiently.

Pakistan's Indus Basin aquifer is under severe and spatially uneven pressure. Water-table depth varies greatly across Punjab, so exceptional deep-water locations should not be presented as a province-wide average. What is well established is the direction of travel in heavily pumped areas: groundwater levels are declining, pumping lifts and energy requirements are rising, and irrigation economics are becoming more vulnerable. The problem is intensified where extraction increases while infiltration and recharge opportunities are reduced by compaction, hardpan, surface sealing, rapid runoff and loss of soil organic structure.

The mechanism is visible in PQNK field evidence. Where hardpan has been broken and biological structure, roots and surface cover are restored, rainfall can enter the soil profile instead of rapidly leaving the field as runoff. PQNK field video evidence shows heavy rain entering protected soil while water is being shed and concentrated in adjoining disturbed areas. Under suitable soil depth, rainfall intensity and antecedent moisture conditions, this restored infiltration can be very high and can create the deep percolation needed for groundwater recharge. The principle is fundamental: rain must first enter the soil before it can replenish the soil-water reservoir or move downward toward an aquifer. ACI management that compacts the profile and leaves the surface exposed reverses that opportunity, while subsequent groundwater pumping deepens the deficit.

THE NUTRITION BILL: EMPTY CALORIES, FULL HOSPITALS

The most invisible and most consequential cost of the 68-year experiment is the one that every person on the planet pays three times a day: the nutritional deficit in the food produced by a biologically degraded system. The evidence for this deficit is robust, longitudinal, and largely unreported in the mainstream agricultural conversation.

Long-run food-composition records provide evidence that concentrations of a number of nutrients have declined in many crops over the industrial period, although the magnitude differs by crop, nutrient, dataset and method. Davis et al. (2004), comparing USDA data for 43 garden crops between 1950 and 1999, found statistically reliable declines in several nutrients. UK Composition of Foods comparisons extending from 1940 to 2019 likewise report substantial declines in a number of minerals. Taken together with other historical comparisons, the responsible conclusion used throughout this book is that many documented declines fall broadly in the 20-40 percent range, while some crop-nutrient combinations show considerably larger changes. These are not universal percentages and should not be attributed to one cause.

It is equally important to define what these comparisons do and do not prove. Historical food-composition tables were produced with changing cultivars, analytical methods and sampling systems. Yield dilution, breeding priorities, soil conditions, fertilisation, irrigation and other management factors can all influence nutrient concentration. Studies comparing biologically managed and conventional farms, including Montgomery and colleagues (2022), add evidence that management and soil condition can affect mineral and phytochemical composition, but they are not direct tests of matured PQNK production. The decisive PQNK benchmark will be repeated, laboratory-authenticated comparisons of ACI and mature PQNK crops grown under documented field conditions.

The mechanism is therefore best understood as a soil-plant system rather than a single fertiliser effect. Mineral density in food depends on what is available in the root zone, how roots explore the soil, the activity of microbial and mycorrhizal partners, water and oxygen conditions, cultivar genetics, yield level and the plant's allocation of carbon and secondary metabolites. High yield can dilute the concentration of some nutrients when biomass accumulation outpaces mineral acquisition, while degraded rooting and biological function can further restrict access to the wider mineral bank. PQNK's proposition is that restoring the complete soil-root-biological pathway should improve the plant's capacity to acquire and incorporate a broader spectrum of nutrients. That proposition must continue to be measured crop by crop.

The public-health importance of nutrient density is real, but causation must be stated carefully. Diet-related non-communicable diseases and micronutrient deficiencies impose enormous global health burdens, yet they arise from multiple interacting causes, including dietary pattern, excessive calories, ultra-processed foods, physical inactivity, socioeconomic conditions and food quality. Declining nutrient density should therefore not be presented as the single cause of modern chronic disease. The PQNK concern is more fundamental: a food system should be evaluated not only by the calories and tonnes it produces, but also by the nutritional quality of those calories.

We did not set out to build a calorie production system. Yet when tonnes per hectare become the dominant measure of success, calories and bulk can rise while nutritional quality receives far less attention. PQNK restores nutrition to the production objective: yield matters, but what the harvested biomass contains matters as well.

THE BIODIVERSITY BILL: WHAT DISAPPEARED WITHOUT BEING NAMED

A 2021 assessment by Chatham House and UN Environment found that agriculture is a threat to roughly 86 percent of the species assessed as at risk of extinction. IPBES has separately identified agricultural land-use change as a leading driver of biodiversity loss. This is not a statistic about remote wilderness areas. It is a statistic about the fields, margins, hedgerows, water channels, and soil communities of the agricultural landscapes that cover forty percent of the Earth’s land surface. Industrial agriculture has converted these landscapes from biologically diverse, ecologically functional systems into biological monocultures that support, in their most degraded form, almost no life beyond the target crop and its pest species.

One of the most consequential dimensions of biodiversity decline is pressure on pollinators. IPBES assessments show that many pollinating species face elevated extinction risk. Roughly three-quarters of leading global food crop types benefit to some degree from animal pollination, and the economic value of pollination services is measured in hundreds of billions of dollars annually. Agricultural intensification is one contributor to this pressure through habitat simplification and, depending on chemistry and exposure, pesticide effects; climate change, pathogens, invasive species and other land-use changes also contribute. The lesson is not that one pesticide explains pollinator decline, but that food production depends upon ecological partners that conventional accounting often treats as external to the crop.

Below ground, the biodiversity loss is equally severe but even less visible. A single teaspoon of healthy soil contains thousands of microbial species. A teaspoon of heavily managed ACI soil may contain a small fraction of that diversity. The biological functions performed by this underground community, nutrient cycling, water regulation, disease suppression, carbon sequestration, soil structure formation, are performed less efficiently as the community simplifies. The soil becomes progressively more dependent on external inputs to perform functions that its biological community once performed for free, and progressively less capable of recovery because the organisms that would drive recovery are no longer present.

THE CLIMATE BILL: AGRICULTURE AS ACCELERANT

Agriculture and land use contribute materially to climate change through carbon dioxide, methane and nitrous oxide emissions, while agricultural management also changes the terrestrial water cycle. The greenhouse-gas account is only one part of the PQNK climate argument. Soil cover, infiltration, rooting depth, vegetation and land management alter how incoming solar energy is divided between sensible heat and evapotranspiration, how much water remains in the soil, how much returns to the atmosphere through plants, and how moisture is recycled into clouds and precipitation. Recent land-use research confirms that changes in vegetation and evapotranspiration can alter soil moisture, atmospheric moisture recycling and precipitation both locally and downwind.

The scale of atmospheric water movement is enormous. At any one time the atmosphere contains about 12,900 cubic kilometres of water, roughly 12.9 trillion tonnes, and the stock is continually renewed as evaporation and transpiration move vast quantities of water through the air. PQNK's concern is not that this water remains permanently 'stored' in the atmosphere; atmospheric water turns over rapidly. The concern is that human land and water management can redistribute trillions of tonnes through the cycle, changing where water is held, how quickly it evaporates, whether it passes through vegetation, and where it later falls. Bare, compacted agricultural land sheds rainfall and heats strongly; irrigation and groundwater pumping bring additional stored water to the surface; loss of vegetation changes transpiration and moisture recycling. PQNK interprets this large-scale redistribution of water between soil, groundwater, vegetation and atmosphere as a major and under-recognised component of today's climate challenge. Restoring the water cycle therefore requires restoring the soil reservoir, not merely reducing greenhouse-gas emissions.

At the same time, agricultural soils participate directly in the carbon cycle. Plant residues and root inputs can build soil organic carbon when biological inputs exceed decomposition and losses. Intensive tillage, erosion, residue removal and land-use change can reverse that balance and release previously stored soil carbon. The global soil-carbon debt associated with historical land use is therefore evidence of a major transfer from the terrestrial soil pool to the atmosphere. PQNK addresses both sides of the climate problem together: rebuild soil carbon while restoring infiltration, soil moisture, plant cover and the terrestrial water cycle.

THE FARMER'S BILL: DEBT, DESPAIR, AND DEPARTURE

The costs described so far in this chapter are systemic, borne by the soil, the water, the biological community, the climate, and the consumers of the food produced. But the most immediate cost of the 68-year experiment is borne by the farmers who implement it: the men and women whose daily decisions about inputs, irrigation, and management are the ground-level expression of the industrial agricultural system.

The economic pressure on Pakistani farmers is substantial and increasingly visible in official data. Farm profitability is squeezed when input prices rise faster than crop prices or when weather and water stress reduce output. Pakistan's Economic Survey 2024–25 reported that fertiliser nutrient offtake during July–March FY2025 fell 14.1 percent year on year; the Survey identifies the economic slowdown, particularly subdued wheat market prices, as the primary factor reducing demand. Farm-level research in Punjab also finds input prices to be an important determinant of profitability. These data do not prove that every farmer is worse off than in 1980, but they support the broader pattern described here: rising production costs, volatile crop returns and water stress have placed sustained pressure on farm margins.

Rural-to-urban migration is part of this economic picture, and its strongest driver is the labour economy of farming itself. As production costs have risen faster than crop prices, farm margins have compressed, and with them the wages a farm can pay. Agricultural work is also hard and exposed: long hours outdoors, often in extreme heat, with earnings tied to season and task rather than a fixed working day. Towns and cities offer wages that are higher and more regular, defined hours and better working conditions, and that contrast has drawn much of the younger, able-bodied rural workforce off the land. Better access to schooling and healthcare adds to the pull, and in areas of highly unequal land ownership the subordination, insecurity and unequal access to redress that come with tenancy and dependence on a landholder are a further push. Water and climate stress compound all of this: World Bank evidence links water deficits and dry-rainfall shocks with increased out-migration in rural Pakistan, particularly where livelihoods depend heavily on agriculture. Marriage and family movement remain important in their own right. For farming households, leaving the land can be both an adaptation strategy and a signal that the local agricultural economy is no longer providing a secure livelihood.

THE CUMULATIVE AUDIT: PUTTING NUMBERS TO THE CATASTROPHE

Indicator	Earlier documented benchmark	Current/latest documented condition	What the evidence supports
Soil organic matter, Punjab	No single province-wide 1958 baseline used	Commonly <1% in intensively cultivated soils; lower in some locations	Large areas have very low organic matter; rebuilding carbon and biological structure is a priority
Groundwater, Punjab / Indus Basin	Historical depths varied strongly by location	Declining levels and rising pumping stress in heavily extracted areas	Extraction exceeds recharge in important agricultural zones; recharge opportunity must be restored
Global soil erosion	No invented 1960 comparator	~24 billion tonnes of fertile soil lost annually	Erosion remains a major global loss of agricultural capital
Food nutrient density	Historical national food-composition records from 1940s-1950s	Many documented nutrient declines broadly 20-40%; some larger	Declines vary by crop, nutrient, cultivar, method and management; not a universal percentage
Pollinators	Long-term global baseline incomplete	Many pollinator species face elevated threat; ~3/4 of leading food crop types benefit from animal pollination	Agriculture depends on biodiversity that is insufficiently valued in yield-only accounting
Atmospheric water cycle	Natural hydrological cycle before modern land/water intensification	~12.9 trillion tonnes of water present in atmosphere at any one time; continually recycled	Land use, vegetation, irrigation and groundwater pumping alter storage, evapotranspiration and moisture recycling
Large aquifer stress	GRACE-era measurement unavailable before satellites	21 of 37 largest aquifers were reported as losing water in the landmark GRACE assessment	Groundwater depletion is a measurable global agricultural and water-security risk
Farmer input exposure, Pakistan	Lower-input historical systems not directly comparable in one national series	High input prices, subdued crop prices and water stress continue to pressure farm economics	Input dependence exposes farmer margins to energy, fertiliser, water, credit and market shocks

The above table consolidates selected measurable dimensions of the 68-year experiment. It is deliberately conservative. Where a defensible 1958 or 1960 numerical baseline is not available, the table does not invent one. Instead, it distinguishes an earlier documented benchmark from the current or latest documented condition and states only the conclusion that the evidence can support. This is a directional audit, not a claim that every change has one cause.

Pedaver Research has separately developed an economic framework for estimating the annual cost of degenerative agriculture and the potential restoration dividend from PQNK. Earlier working estimates identified approximately $1.9 trillion in annual avoidable costs and approximately $2.8 trillion in potential restoration benefits, giving a combined transformation opportunity of about $4.7 trillion per year. These are Pedaver analytical estimates, not figures issued by FAO, IPCC or another international body. Their methodology, assumptions, boundaries and avoidance of double counting belong in Chapter Fourteen, The True Cost. Chapter Eleven therefore records the framework but does not use the aggregate monetary estimate as proof of the biophysical case presented here.

PAKISTAN IN THE GLOBAL CONTEXT: A MICROCOSM OF THE MACRO

Pakistan's agricultural crisis is not unique. It is the local expression of a global pattern that plays out wherever the ACI package has been adopted at industrial scale. What makes Pakistan's case instructive is the compression of the timeline and the clarity of the causation: the Green Revolution arrived in Pakistan in the 1960s with a precision and intensity that allows the trajectory of damage to be traced almost year by year.

Pakistan has, within the 68-year window, experienced every stage of the ACI damage sequence: the initial yield improvement; the subsequent soil organic matter decline; the rising input costs that compressed margins even as absolute yields improved; the water table collapse that now threatens the irrigation system on which those yields depend; the salinity buildup that has rendered significant areas of formerly productive land unable to support crops; the pest resistance escalation that has driven pesticide costs and application frequency upward in many crops; and concerns over nutritional quality alongside a paradox of increasing food production and increasing malnutrition.

Pakistan is also, because of its geography, demographics and agricultural potential, one of the countries with much to gain from reversing this trajectory. Indus Basin soils, however degraded under decades of intensive cultivation, still contain large mineral reserves and can rebuild biological structure under different management. Rainfall is uneven across Pakistan and cannot replace irrigation everywhere, but every millimetre captured in the soil reduces the amount that must be supplied from canals or groundwater. The farm workforce, land base and markets are present. The missing step is to treat soil restoration and Soil Moisture Management as national water and food-security infrastructure rather than as marginal agronomic practices.

WHAT THIS CHAPTER HAS ESTABLISHED

The 68-year experiment in industrial agriculture has produced a measurable record of gains and costs. Yield and labour productivity increased substantially, but many intensively managed systems also accumulated losses in soil function, groundwater security, biodiversity, input independence and, in some crops and nutrients, food quality. These outcomes should not be reduced to a single cause, nor should every farm be assumed to follow the same trajectory. The larger conclusion is nevertheless unavoidable: annual yield alone is an inadequate balance sheet for agriculture. A system that consumes soil, water, biological capital or farmer solvency to maintain output is drawing down assets that the yield statistic does not record.

Pedaver's economic work places this wider balance sheet into monetary terms, but the full methodology is reserved for Chapter Fourteen, The True Cost. The evidence established here is the physical and biological foundation for that later accounting. The next question is institutional: if so many warning signals accumulated during the 68-year experiment, why did agricultural research and policy continue to organise themselves primarily around the input-response model? That is the subject of Chapter Twelve.

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Chapter Twelve: Captured Science, How Agricultural Research Became a Tool of the Input Supply Industry