SOCIOECONOMICS

The ecology of rural poverty

Feedbacks between biological and economic systems can lead to persistent poverty traps for the world's rural poor. A combination of economic, ecological and epidemiological modelling helps unravel how these feedbacks and traps occur.

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One billion people remain below the international poverty line[1]. For many of these people, their circumstances act to keep them there. No matter what they do, they are stuck. In the economics literature, poverty traps are attributed to nonlinearities in the capital accumulation process — if you do not earn enough to invest in increasing future earnings, you will never earn enough for such investment[2]. While economists have discussed a range of possible causes of household-level poverty traps, they have tended to shy away from close examination of the underlying dynamics of the systems that produce such nonlinearities[3]. For those trapped in poverty in rural areas, where capital is typically biological (themselves plus their livestock and crops), insights into the underlying dynamics may already be available in the form of ecological and epidemiological models[4,5]. What is needed is a combination of economic, ecological and epidemiological models, to better understand the interactions between wealth accumulation and the environment in rural settings. Writing in *Nature Ecology & Evolution*, Ngonghala et al. report an important step in this direction, highlighting the benefits of model combination, including, even at this early stage, important policy implications[6].

Subsistence farmers have to balance meeting their family's basic needs, including nutrition and healthcare, with investments in land, livestock and crops, including protecting their capital stock against pests and other natural enemies. They have to do this in environments characterized by high rates of infectious diseases and where natural enemies such as pests and pathogens are common. Their balancing act is complicated by the interactions between wealth accumulation, the farmer's health and associated productivity, and the health of their biological capital. If they are not healthy enough to work, their income will suffer; if their livestock are not protected from disease, their income will suffer and their health may suffer; and if their income suffers, everything suffers. These interactions build a complex web of influence and feedback over time. The critical issue is that the outcome of this balancing act is to a large extent shaped by the environment in which it is being attempted. Figure 1 compares the implications of an environment that is characterized by epidemic disease and numerous natural enemies with one that is not. In the first case, the environment leads to a poverty trap. In the second case, despite the same starting income, the conducive environment results in income heading upward.

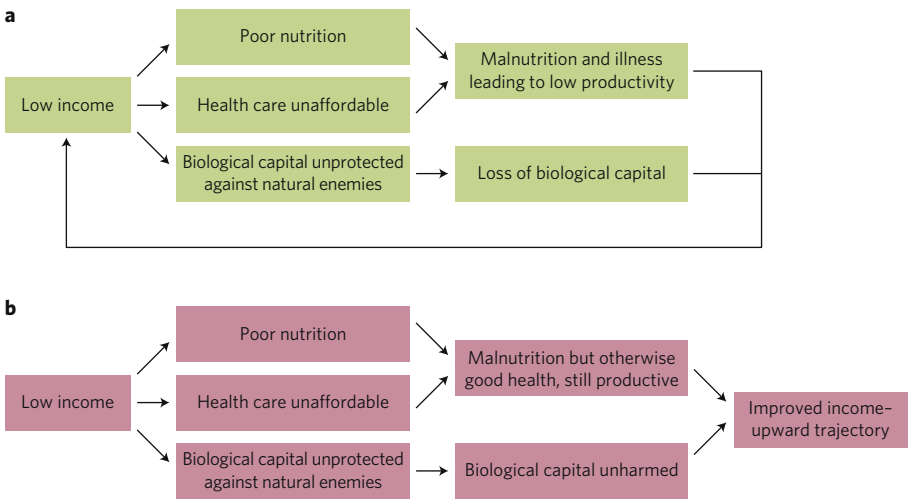

Figure 1 | Rural environments and wealth accumulation. **a**, Environment characterized by epidemic infectious disease and natural enemies. **b**, Environment characterized by low risk of infectious disease and natural enemies.

Ngonghala et al. take a simple economic model of wealth accumulation and gradually extend it by incorporating epidemiological and population ecological models. With each extension they further unpack the underlying mechanisms through which negative feedbacks between human health, other forms of biological capital and wealth accumulation occur, and how such mechanisms can lead to poverty equilibria, that is, poverty traps. As is often the case, the models are ahead of the data required to calibrate them. The authors are restricted to examining the behaviour of the models across parameter space. They do not have the data to say which combinations of parameters, and therefore which outcomes, are more likely. What they can say is that relatively few combinations lead to sustained wealth accumulation or bistability (that is, where the wealth trajectory is determined by the starting point, with a high enough starting wealth leading to accumulation and anything lower leading to persistent poverty). The majority of combinations lead to sustained capital loss. This demonstrates the strength of the negative feedbacks and how important it

is for several factors to be simultaneously conducive for wealth accumulation to occur.

Those living in persistent poverty are clearly not on the sustained wealth accumulation path, but could be in an environment characterized by bistability or a stable poverty equilibrium. If the environment is characterized by bistability, then a big push of support, such as a capital transfer of livestock or seeds, would help them over the hurdle and sustained accumulation would begin. If the environment is characterized by a stable poverty equilibrium, a big push will provide temporary respite, followed by a return to poverty. The models presented by Ngonghala et al. suggest that poverty reduction in environments that lead to a stable poverty equilibrium must focus on changing the parameters of the system — for example, by decreasing disease risk through improved public health interventions and improved healthcare. This is a critical insight as it suggests that without an understanding of the underlying dynamics, intervention designers interested in addressing poverty traps may well opt for the wrong type of approach. A research priority must therefore be the collection of appropriate data to identify what types of approaches are needed where.

Examining how interaction in rural areas between people's health, their biological capital and their environment affects their chances of escaping poverty is a useful exercise. This approach would be more useful if it were extended to consider the interaction between the environment and human behaviour. Ngonghala et al. mention this possibility in regards to model extensions that consider savings rates and health behaviour as dynamic variables determined by human decisions, which are themselves determined by the environment. It will be interesting here to consider not only how the environment determines which options are available, but how the environment influences both the way in which options are evaluated and the way in which decisions are made. The impact of poverty on cognitive function, for example, is receiving increasing attention[7]. Longer-term models could consider the impact of the environment on people's neurological development[8] and internalization of social norms. People are shaped by their environments and in turn act on those environments; an obvious point when discussing evolution and ecology, but not so obvious in economics and poverty reduction debates. ❐

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Competing interests

The author declares no competing financial interests.