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jorgen.randers@bi.no

Jorgen Randers[1] response to

A scientific review of the Earth4All "model",
presented to the Club of Rome
on January 11, 2024
by
K. Vala Ragnarsdottir, Harald U. Sverdrup, Hördur V. Haraldsson, Birgit Kopainsky
"RSHK"

Executive summary

The Earth4All-global model is harshly criticized in a memo written by a group of model builders headed by K. Vala Ragnarsdottir. Below follows my first response[2]. For readers outside the field of mathematical model building, it is crucial to understand that the RSHK criticism and my response amounts to nothing more than a continuation of the debate among different subschools of system dynamics about what is the "true" purpose and "correct" practice of model building[3].
It should come as no big surprise that intense "religious" wars exist among model builders who pursue the difficult (impossible?) task of conceptualizing models which are sufficiently transparent (simple) and sufficiently correct (precise) to be useful in the development of improved policy for the world – on a 100-year time scale.
The Club of Rome (and its financiers) should be complemented for advancing the global policy debate through verbal books like *Earth for All*, and for furthering the use of simulation models to help ensure clear thinking.
And for helping make clear that the model is not the *source* of the message, only a tool to support consistent thinking.

[1] Jorgen Randers, Professor emeritus, Department of Law and Governance, BI Norwegian Business School coauthor of *Earth for All* (2022) and many other reports to the Club of Rome. Built the Earth4All global model.

[2] I am sure that my many colleagues during the many years of building the Earth4All model and its forerunners support my view. But I have chosen to write this note in my name only, in order to take the brunt of the rather personal insults that clutter the RSHK "scientific" review. My colleagues are in the process of preparing an targeted response to the many unfounded and mistaken criticisms of the Earth4All model.

[3] See Clancy T et al. 2023. "Reconciling the four schools of thought in the debate on quality". *System Dynamics Review* July pp 277-294. Clancy discusses the goals and success criteria of the Empirical, Structural, Pragmatic and Methodological sub-schools of system dynamics. I solidly belong in the Structural sub-school (that seeks to explain observed dynamics), while RSHK write as members of the Empirical sub-school (that seeks truth in the form of numerical fit to observed data). One should not think that such nuances should be able to drive religious wars – but they certainly do!

Introduction – the role of modeling in the Earth for All book
The urgent message of the *Earth for All* project and book is simple and clear: the world needs 5 transformative actions to increase the wellbeing of the global majority towards 2100. Importantly this message does *not* rely on the Earth4All system dynamics model that was built as part of the project. Luckily one does not need mathematics and simulation to reach this conclusion. The *Earth for All* message can be presented and defended in words – as is (well) done in the book.

The E4A model supports, quantifies, and assesses the long-term impacts of the message but the model is *not* the source of the message. Needless to say, the E4A model is not a precise representation of the global socio-eco-geo-biological system. As a consequence, it cannot forecast what will happen in detail. All the E4A model can do is to provide broad-brush pictures of future patterns of development. E4A is a very rough approximation of the structures that drive world development, and it was made in order to ensure consistency and keep some order in the verbal argument. The strength of the E4A model is that it is so simple that the user can understand what goes on in the model system, and then use this enhanced understanding to write a clearer verbal discussion in the *Earth for All* book.

So – again needless to say – the E4A model is not the "truth". It is a representation of the world as I (and the team) see it. It is a useful simplification and made in order to explore what are likely effects of 5 turnarounds on average wellbeing. It was made as simple as possible, in order to be transparent and understandable. In light of this: if one does not like the assumptions and formulations of the E4A model, the professional response is to build a new model – using one's own preferred assumptions and formulations. And then, crucially, demonstrate that the new model does indeed invalidate the key messages of the *Earth for All* book.
(Two concrete examples may help clarify: If a model builder does not like the E4A approximation that no one dies before age 60, the professional response would be to build a new population model with age specific mortalities different from zero and demonstrate that this new model invalidates the conclusion that 5 transformations are necessary to increase the wellbeing of the global majority towards 2100. Or if one does not like the E4A approximation that income inequality is mainly influenced by worker share of income and tax rates, the professional response would be to build a new model of the drivers of income inequality in modern society and demonstrate that this new model invalidates the message of *Earth for All*.)

The Club of Rome should be proud to have presented the *Earth for All* message in clear words to the global community. And not feel any obligation to resolve frictions between different modelling paradigms.

Comments on the "scientific" review
Being the main architect of the system dynamics model that was built to support the verbal message in the *Earth for All* book, I have read the scientific review of the Earth4All model with great interest. I am delighted that someone – finally! – has taken the time to look at the model in detail and describe what they see.

Naturally it disturbs me that the reviewers (RSHK) see something which is very far away from what I intended to make when I built the model – following the best practice of the field (which ironically was first described by myself in my book *The System Dynamics Method* from MIT Press in 1980). I am also disturbed by the aggressive tone of the review, and wonder why the authors (three of whom I have known for more than a decade) did not contact

me in their writing process – which would quickly have removed some of the most obvious misunderstandings.

It finally surprises me that RSHK did not pay more attention to the description of model purpose and structure in the *Earth for All* book. Primarily in the Appendix: The Earth4All Model (pp 175-180). But also in the box "How good is the Earth4All model?" (pp 53-55). Both openly present the serious limitations of models like E4A.

Concrete responses
On role of model
The essential starting point is that the perspective and the conclusions of the *Earth for All* do *not* rely on the E4A model. The message is presented and defended in plain language – as it should be in a book that has as its purpose to encourage social change. The role of the E4A model is to *support* the verbal presentation – primarily by ensuring consistent long-term thinking and proper orders of magnitude. Thus it should be reassuring for RSHK – not a point of contention – that the E4A manus was essentially completed *before* the E4A model scenarios were generated.

On forecasting
Needless to say, I do *not* believe that the E4A model can predict the future. The E4A model belongs to the class of system dynamics models that are built to increase understanding in the present. They are very rough approximations – at most capable of indicating general trends. E4A was built specifically to study the evolution towards 2100 of global climate gas emissions (man-made and natural - from energy and agriculture) and the resulting warming. A second ambition was to study the evolution of income inequality – the worker share of income and tax structure. E4A was deliberately made as simple as possible – to help the verbal discourse in a transparent manner. Numerical values in E4A simulations/scenarios are not high precision. It is only the big picture that counts. No competent system dynamicist would ever mistake E4A for a detailed forecasting model. Such models belong to a totally different class of system dynamics models.

On concrete criticisms from RSHK:

1. The model *is* based on a set of cause-and-effect relationships – carefully chosen to recreate the relevant reference modes (GDP growth, investment cycles, inventory cycles, public reaction to environmental decline). The model was designed as simple as possible – which means omitting all variables and relationships which are not *absolutely* necessary to recreate the chosen reference modes. (See my paper to ISDC 2017 on reference modes and basic mechanisms in the macroeconomic core of the E4A model.)
2. The causal diagram of the model is not missing – it is shown on page 178 in the book.
3. The model *does* recreate the broad sweep of history from 1980 to 2020 – see the output graphs from 1980 to 2020 in Figures 2.2 and 2.3.
4. The ludicrous criticism of the population sector is unwarranted. It is correct that in E4A the specific mortality is set to zero for all age groups below 60 – no one dies before they pass 60. This simplification reduces the capacity of the model to make quantitative forecasts. But it greatly simplifies thinking and has little influence on what we are after – long term population trends. This point was proven when the E4A-regional model – enhanced to 20 age groups and including age specific mortality and immigration – was adapted to 10 world regions in a separate study. The resulting world population forecast – calculated as the sum of the 10 regional populations – was

not very different from the E4A global model forecast. Or to be more precise, the differences were so small that they did not modify the conclusions in *Earth for All*.

5. There is no direct representation of banks in the model, only the interest rate – which is determined endogenously by inflation and unemployment. Thus, the model reflects modern monetary theory, which posits that the money is not limited but is increased whenever a bank gives a loan – which commercial banks do when it is profitable.
6. The model does not balance energy, mass, materials, food, and carbon, because I am convinced (after decades of pondering, see below) that these resources are not crucial in determining global emissions and inequality towards 2100. They or substitutes will be made available to producers first of all because the total cost of resources (raw materials, primary sector of the economy) is a small fraction of global GDP. If RSHK believe otherwise, as many do, they should make a model based on their assumptions (World7?) and show that it invalidates the message of *Earth for All*.
7. The E4A model includes many delays (SMOOTH functions) to mimic the sluggish nature of the world system – to reflect the fact that decisions do not immediately lead to change in the physical world.
8. Most of the exponential functions (EXP functions) in the E4A model represent endogenous decay processes. They are not exogenous drivers.
9. It is meaningless to run a model that is explicitly made to study the next 40-80 years for several hundred years.

On the aggressive tone

As mentioned, I am disturbed by the aggressive (and unscientific) tone of the review. My guess is that it is prompted by one central assumption underlying the E4A model – an assumption which conflicts with the professional view of RSHK. The E4A model assumes that resource (materials) scarcity will *not* be a main determinant of global dynamics towards 2100. Instead, the E4A model takes the view that the main (negative) influence on human wellbeing will come from climate change and inequality. This is not a simple and unfounded choice of perspective: It is the result of decades of work – reported among others in my fourth report to the Club of Rome in 2012 called *2052 – A Global Forecast for the next Forty Years*, and then again in my fifth report to the Club in 2016 called *Reinventing Prosperity*, as well as in Earth3-project report "Transformation is Feasible". I repeat that if RSHK disagree they should build their own model based on their preferred perspective and demonstrate that this model invalidates the message of *Earth for All*.

Conclusion

There is no reason for the Club of Rome to disassociate itself from the *Earth for All* report. The report presents a clear problem analysis, recommends clear action, and the message is now spreading – both thanks to purposeful financers, and because of the message is fundamentally sound: Something needs to be done now to improve wellbeing of the global majority.

The message is highly political and the fact that it is disliked by those who hold different views should not surprise anyone. If such opposition is based on a different world model, everyone would benefit from seeing this alternative model, and particularly runs from that model that invalidates the message of *Earth for All*.

I hope that crass criticism from well reputed players like RSHK may help increase the interest in the *Earth for All* message. Just like the outrage of neoclassical macroeconomists in the spring of 1972 helped *The Limits to Growth* go ballistic.