

4.1. Farming Futures: Modeling the effects of climate change on agriculture

Objectives

Global warming is coming; there is now no question about it. The consequences are still to be determined in detail, but agriculture will undoubtedly be changed over the next 20 years.

Agricultural research has a long lead-time. A recent breakthrough in drought tolerance for beans at CIAT, although not costing more than a few million dollars, took nearly 25 years to deliver the goods. This means that scarce research resources have to be targeted with great care. This has never been easy, but with the moving goalposts of Global Climate Change upon us, the job has become much more difficult. We need to know what will be needed, and where it will be needed, **now**, to plan the next 25 years of research (Figure 23).

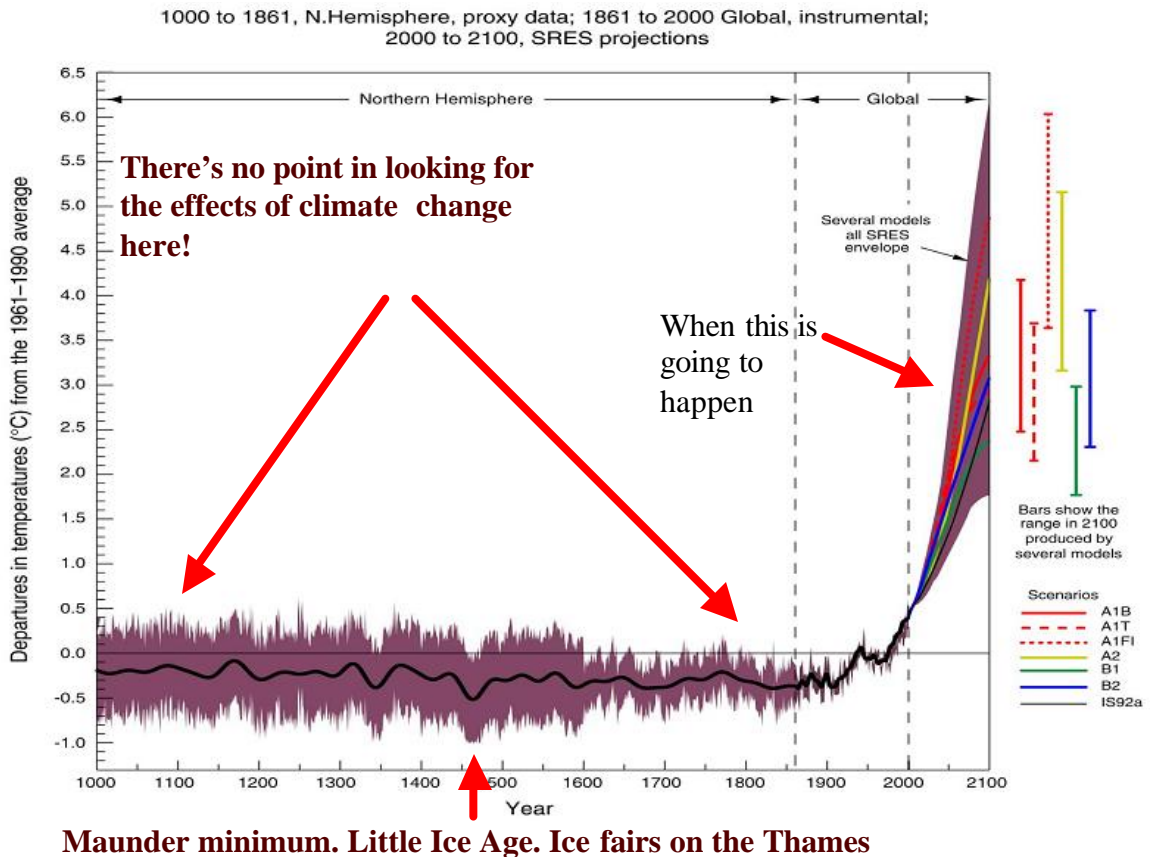


Figure 23. Variations in the Earth's surface temperature, 1000 to 2100.

We are obviously in an area where experience is of little use beyond our knowledge of the theory of plant growth and development. We have never seen the sort of changes that

are coming and so we are reduced to guessing or modeling. Guessing is never a good idea.

Methods

We must resort to modeling the system. This is fraught with problems, but it can be done. We have shown (Jones and Thornton, 2002¹) that crop process models can be linked to the output from GCMs to estimate the effects of climate change on agriculture in the tropics. We have now extended those studies to include an assessment of potential maize yields in the year 2055 for Africa and Latin America. We used the outputs of the HADCM2 model and interpolated the changes in climate onto the CIAT climate grids. Simulated weather was then generated using MarkSim. For each of 20 simulated years, the model CERES maize was used to estimate yield.

Results

The results show three main scenarios with which we will be dealing:

- (1) There will be areas (particularly in the highlands) where some crop yields may improve – *It is imperative that research in these areas should make the maximum use of any potential gains, because there will not be many places where this will apply.*
- (2) Quite large areas may show minor changes in yield potential, but will require differently adapted varieties and probably some shifts in crop mixes and agricultural practices. *These cases will require carefully planned research in cultivar development and farming practices.*
- (3) A significant number of areas will require major intervention because of potential complete crop failure. *Major changes in the agricultural economy of these areas will be needed. Agricultural technology may be unable to solve these problems, but farming systems research may be able to warn decision makers of the possible consequences.*

Maize (the test case we decided to look at) is a C₄ plant probably better able to stand up to rising temperatures than most other crops. We chose it because we know the model used has been in use for about 30 years, and has been proved in most environments. Here are some examples of what we found:

¹ Jones, P. G.; Thornton, P.K. 2002. Spatial modeling of risk in natural resource management. *Conserv Ecol* 5: 27. [on-line] URL: <http://www.consecol.org/vol5/iss2/art27>.

The first is some good news for Ethiopia (Figure 24). It is not often that happens! Ethiopia is not a major, maize-growing nation, but the indications show that cereal growth with C₄ plants such as teff could be improved in quite a few areas. However, you will note from Figure 24 that local decompensations will occur. This is a typical case of the class 1 climate change problem. There are benefits to be had, but the agriculture of the area will have to be rebalanced to gain the benefits. Of course, the actual crops of the area have to be modeled under GCM conditions to assess the true situation.

Present yield

Yield change to year 2055

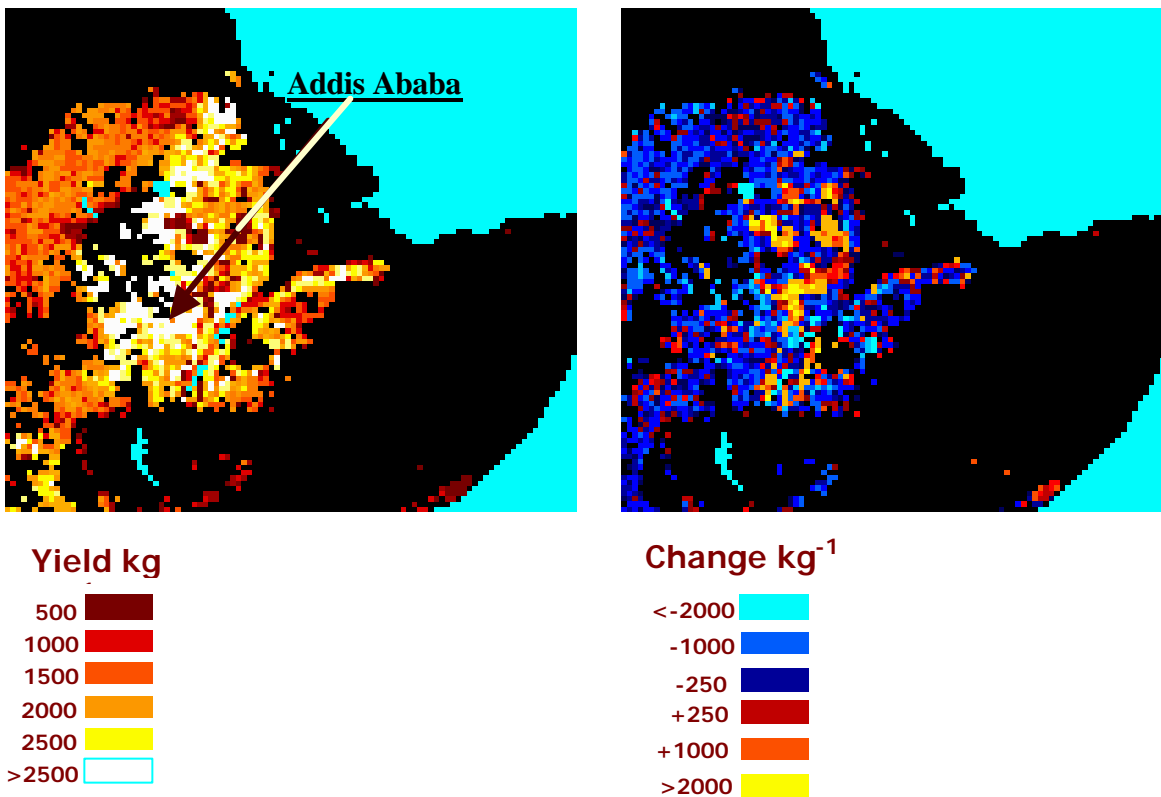


Figure 24. Predicted maize yield changes for Ethiopia to year 2055.

A typical class 2 case can be found in Brazil (Figure 25). Here we have a mosaic of minor yield decreases associated with local increases in yield potential. This is obviously of immense importance to the farmers of the region, but could be handled with judicious application of agricultural science without major catastrophe. Knowing just what new varieties will be needed will help to capitalize on the benefits and reduce the possible losses.

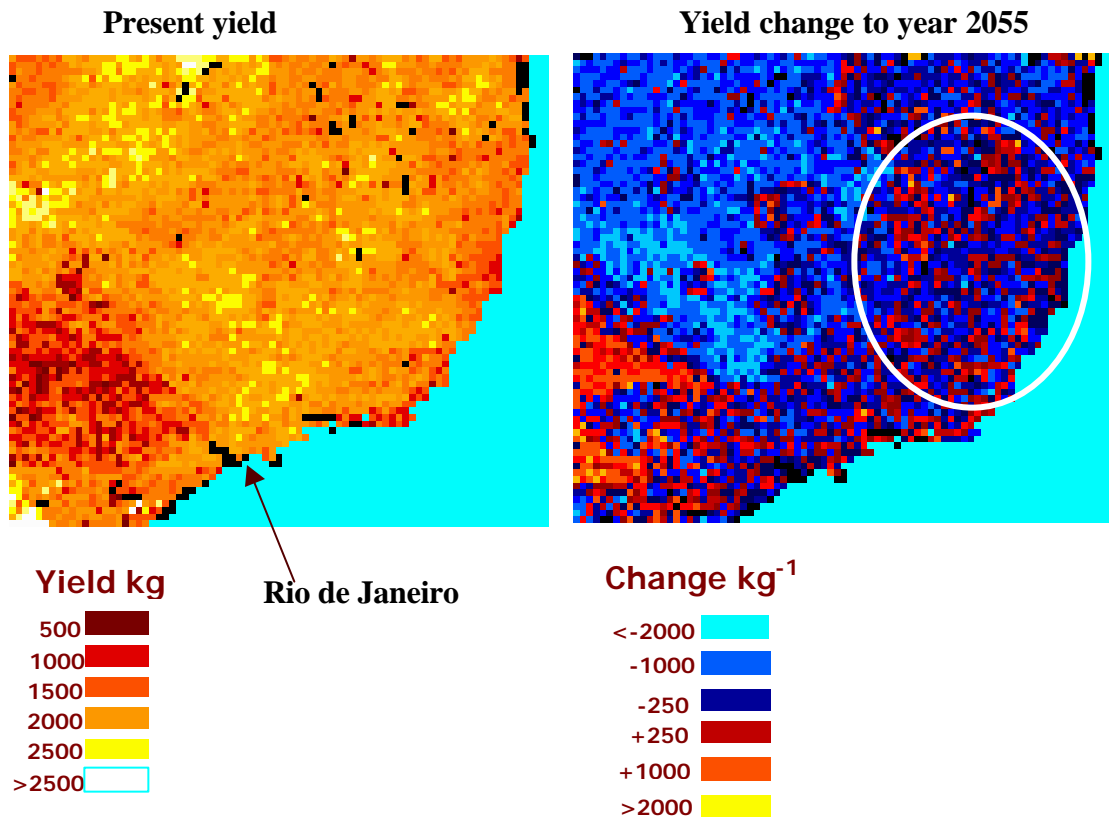


Figure 25. Predicted maize yield changes for Bahia, Brazil to year 2055.

This dry area in Venezuela (Figure 26) exemplifies the class 3 situation. When the markets have been right, this has been a major maize-producing area. It is dry, mainly scrubland, but can produce well under certain circumstances. The change in wind patterns will mean that it becomes much drier, and will probably have to go back to extensive grazing. The crop production of Venezuela does not look like a happy prospect in the next 50 years, and for rainfed crops like maize it would appear that a major shift might be indicated. Venezuela, of course, has much irrigable land, and so this may not be a major problem if the social implications are dealt with appropriately.

Present Yield

Yield Change to Year 2055

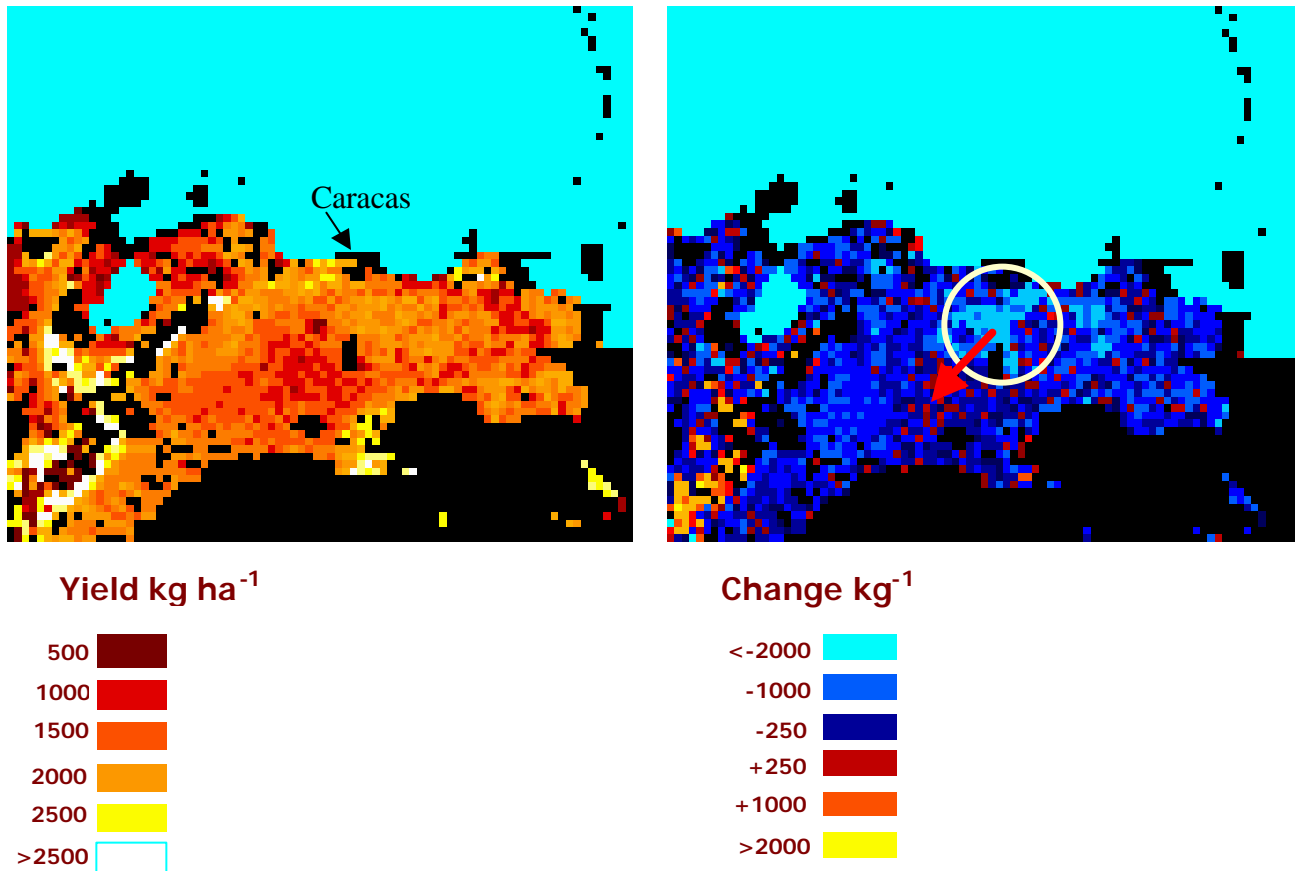


Figure 26. Predicted maize yield changes for Venezuela to year 2055.

Outputs

These examples show some of the complexity of the problem we are facing. Planning for agricultural research under these conditions needs pre-knowledge. We have shown that we can do this with one crop, but we need to do much more. The C₃ crops behave completely differently, and varietal adaptation is the key to successful agriculture. These results have been used to develop project proposals. The major one, entitled Farming Futures, is included in the Climate Change Global Challenge Program (CCGCP) and would involve a budget of \$M2.6 over 4 years. A cut-down version of this, to try to classify the areas showing different response types, would take minimal funding and take a very quick look at the situation to assist in the planning for the CCGCP.

Contributors: Peter G Jones (consultant, CIAT); Philip K Thornton (consultant, ILRI); Glenn Hyman