# Ex-ante Impact Assessment of Stay-Green Drought Tolerant Sorghum Cultivar under Future Climate Scenarios

S Nedumaran[1], Cynthia Bantilan[1], Piara Singh[1], P Abinaya[1], Ashok Kumar[2], Santosh Deshpande[2], Amanda Palazzo[3], Daniel Mason-D'Croz[3], D KumaraCharyulu[1] and Gerald C Nelson[3]

[1]Research Program – Markets, Institutions and Policies, International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), Hyderabad, India; [2]Research Program – Dryland Cereals, ICRISAT; [3]Environment and Production Technology Division, International Food Policy Research Institute (IFPRI), Washington DC, USA

## Introduction

- Sorghum [*Sorghum bicolor* (L.) Moench] is grown in the hot and dry agro ecologies of Asia, Africa, the Americas and Australia.
- It is globally the fifth most important cereal crop, and the dietary staple of more than 500 million people in 30 countries.
- Improving the productivity of sorghum in marginal environments will help food insecure poor farmer families gain a large share of the potential food security benefits.


*Stay-green sorghum, where leaves and stems are green even when panicles are mature.*

## Objective of the study

To evaluate the ex-ante welfare benefits of drought tolerant sorghum under future climate condition, which provide evidence based results for prioritizing research and investments.

## Drought tolerance sustains food production in the drylands

- Drought is the principal constraint to crop production in the drylands of sub-Saharan Africa and Asia.
- Given the severity of drought and the limited scope for investments and expansion of irrigation facilities, there is a greater challenge for breeders to develop technologies that provide greater resilience to agricultural production.
- A stay-green trait has been associated with post-flowering drought tolerance in sorghum, which would stabilize productivity and contribute to sustainability of production systems.
- At ICRISAT, six stable and major Qualitative Trait Loci (QTL) were identified for the stay-green trait and are being introgressed through MAS into elite genetic backgrounds.

## Methodology

- The integrated modelling framework of IMPACT (Figure 1) is used to estimate the welfare benefits of sorghum drought technology adoption.
- It has a global coverage comprising 281 spatial units, and models the demand, supply and trade of 40 commodities of crops and livestock, wherein world agricultural commodity prices are determined annually at levels that clear international markets.
- The model incorporates yield advantage of promising technology and climate effects from the DSSAT modelling results as a shifter in the supply functions.
- The simulation results were used to estimate the changes in consumer and producer surplus using the principles of economic surplus.
- In addition, return on investment of technology adoption are also estimated.

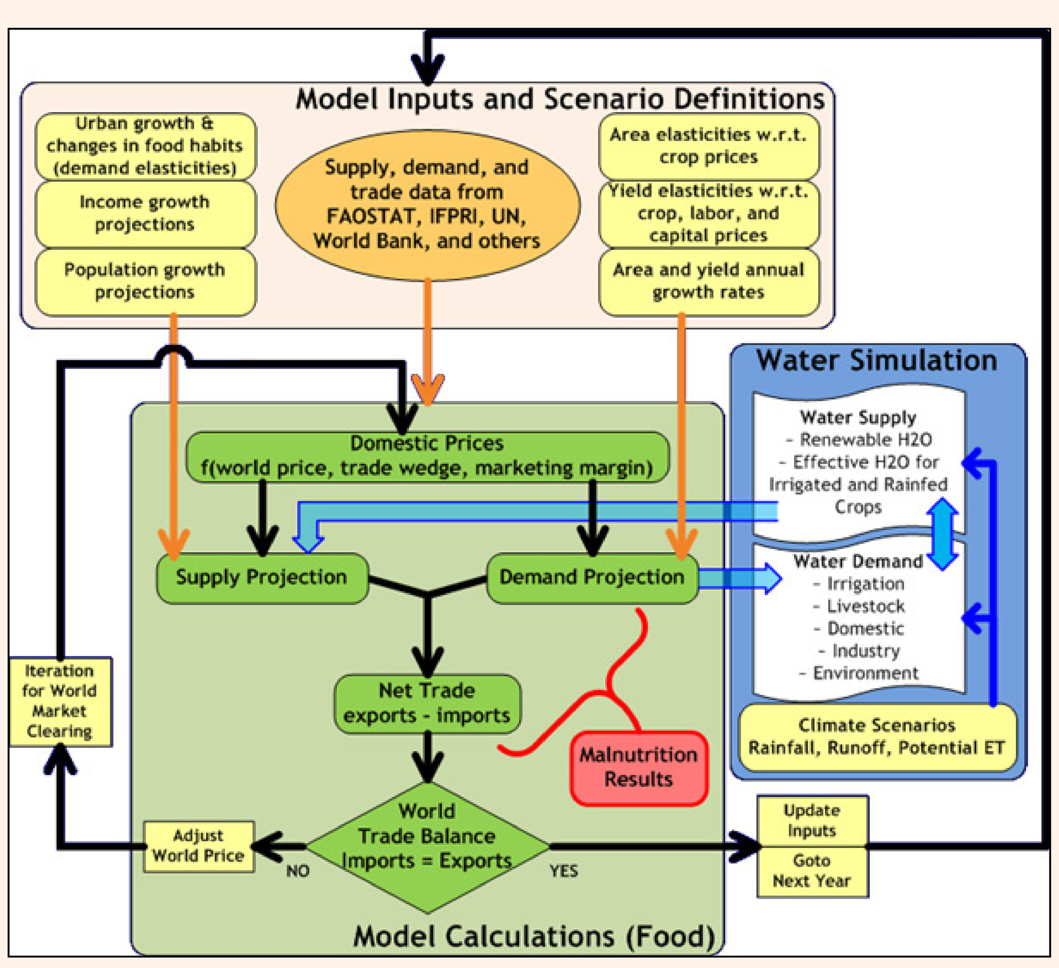



*Figure 1: IMPACT model framework (Nelson et al. 2010).*

## DSSAT Sorghum Model

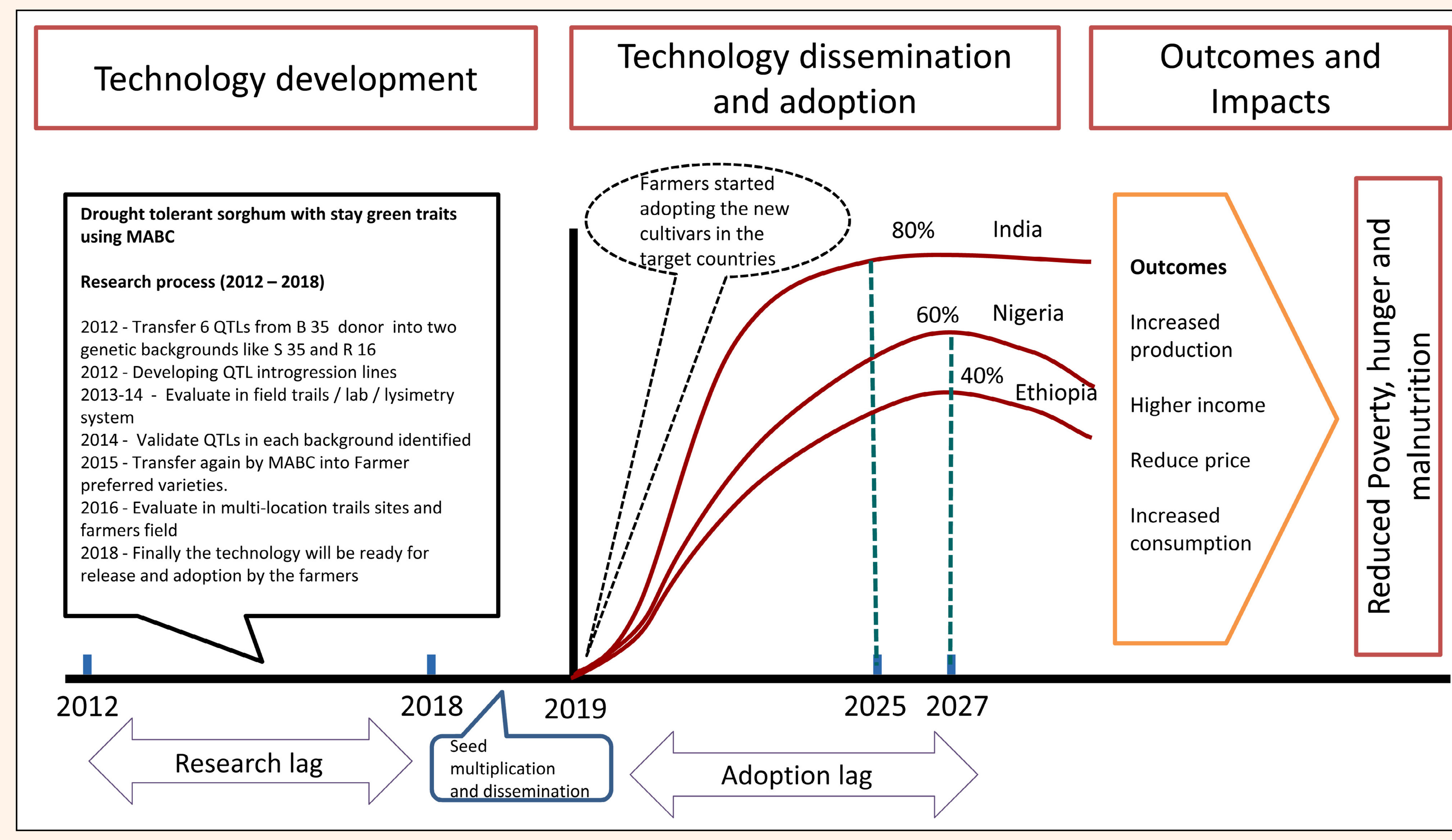
- The DSSAT crop simulation model is used to develop virtual drought tolerant cultivars to estimate the yield advantage over the baseline cultivar.
- The drought tolerant trait is combined with yield increase trait (eg, higher photosynthesis efficiency by 10%), the increase in yield ranges from 23% to 26% in current climate and 31% to 33% in a warmer climate (+2°C) (Table 1).

**Table 1: Grain yield (kg/ha) of baseline cultivar CSV 15 and virtual cultivars at Akola and Indore sites in current and future climate scenarios.**

| | Akola N*= 13 | | | | Indore N= 13 | | | |
|---|---|---|---|---|---|---|---|---|
| Virtual cultivars | Current Climate | % change | 2 °C | % change | Current climate | % change | 2 °C | % change |
| Baseline cultivar** | 3629 | | 2573 | | 3539 | | 3019 | |
| Base + DT | 3713 | 2.3 | 2613 | 1.6 | 3742 | 5.7 | 3182 | 5.4 |
| 10% LD + DT | 4418 | 21.7 | 3445 | 33.9 | 4097 | 15.8 | 3715 | 23.1 |
| Base + 10% YP+ DT | 4458 | 22.8 | 3429 | 33.3 | 4456 | 25.9 | 3950 | 30.8 |
| 10% SD + 10% YP+DT | 3512 | -3.2 | 2328 | -9.5 | 3844 | 8.6 | 3052 | 1.1 |
| 10% LD + 10% YP+DT | 4965 | 36.8 | 4195 | 63.0 | 4848 | 37.0 | 4442 | 47.1 |

Note: * N = number of years of simulation; **Standard baseline cultivars without any changes in genetic coefficients, DT = Drought Tolerant, SD = short duration, LD = long duration, and YP = yield potential traits.

### Technology development and adoption pathway




## Results and Discussion

- Drought tolerant sorghum cultivars will generate global welfare benefits of about US$ 1481 million under current climate conditions (Table 2).
- Under CSIRO climate scenarios, the adoption of new technology increases the global net welfare benefits over and above the benefits obtained under the 'no climate change' condition.
- The Internal Rate of Return for the sorghum drought research investment under no climate change condition is about 59% and Benefit-Cost ratio, about 292:1 (Table 2).

**Table 2: Global net welfare benefit indicators under climate change scenarios.**

| | Climate change scenario* | | | | |
|---|---|---|---|---|---|
| Welfare and returns on investment | No climate change | MIROC 369 AIB | MIROC 369 B1 | CSIRO 369 A1B | CSIRO 369 B1 |
| Net Welfare change (NPV, m US$) | 1481.93 | 1443.33 | 1450.48 | 1769.04 | 1662.57 |
| Cost (NPV, m US$) | 5.06 | 5.06 | 5.06 | 5.06 | 5.06 |
| Benefit-Cost ratio | 292.79 | 285.16 | 286.58 | 349.52 | 328.48 |
| Net benefits (NPV, m US$) | 1476.87 | 1438.27 | 1445.42 | 1763.98 | 1657.50 |
| IRR (%) | 59.03 | 58.35 | 58.52 | 60.56 | 60.01 |

*Note: *The climate scenarios used in the analysis are the MIROC (MIR A1B and B1) scenarios representing warmer and wetter climates while the CSIRO (CSI A1B and B1) scenarios represent the dry and relatively cool.*
*Source: Authors' calculation.*

## Change in welfare indicators

- The adoption of new drought tolerant technology can increase the food availability in the target countries ranging from 59.1 Kcal per capita in Sudan to 5.2 Kcal per capita in India for US$1 million investment in sorghum research (Table 3).
- The reduction of the number of children malnourished below five years of age in the target countries ranges from 2,198 in Eritrea to about 97,114 children in Nigeria.

**Table 3: Impact of adoption of drought tolerant sorghum cultivar on daily kilocalorie availability, malnourished children and population at hunger risk under no climate change.**

| Region | Target Countries | Kcal-C Ratio | Malnourished-C Ratio |
|---|---|---|---|
| WCA | Burkina Faso | 52.0 | -24127.7 |
| | Mali | 8.9 | -3319.6 |
| | Nigeria | 31.6 | -97114.8 |
| ESA | Eritrea | 15.2 | -2198.6 |
| | Ethiopia | 21.9 | -32155.6 |
| | Sudan | 59.1 | -44775.7 |
| | Tanzania | 21.8 | -24792.0 |
| South Asia | India | 5.2 | -48686.7 |

Note: KCal-C_Ratio: Change in Food availability over Cost (KCal per person/million $US); Malnourished-C_Ratio: Change in Malnourished children - cost ratio (children/million $US) Source: Authors' calculation

## Conclusion

- The analysis indicates that the economic benefits of drought tolerant sorghum cultivar adoption in the target countries outweighs the cost of developing this new technology, and also increases food availability and reduces child malnourishment.
- Therefore, investment in drought tolerant sorghum research is inevitable and will irrefutably prove to be fruitful under future climate scenarios.

ICRISAT Science with a human face
International Crops Research Institute for the Semi-Arid Tropics
Aug 2012