# International collaboration delivers novel tool-and-training package for rapid ex-ante evaluation of agricultural innovations in smallholder systems

A CSIRO-CIMMYT collaboration

SECU2020_515

**Marta MONJARDINO[1], Geoff KUEHNE[2], Khondoker MOTTALEB[3], Gideon KRUSEMAN[3]**
[1]CSIRO Agriculture & Food [2]Meaningful Social Research – AUSTRALIA [3]CIMMYT Socioeconomic Program – MEXICO

www.csiro.au

*Value-Ag* was used to evaluate the economics of adoption of Conservation Agriculture to intensify traditional smallholder systems in central Mexico.

## Introduction

Ex-ante evaluation of agricultural innovations requires knowledge of systems economics and risk as well as broader adoption drivers. CSIRO tool-box *Value-Ag* was used in a CIMMYT workshop setting to explore whole-farm performance and scaling potential of a strategic innovation – Conservation Agriculture (CA) – in the context of production risk and household dynamics in a smallholder farming system in central Mexico.


**Fig 1.** The case-study farm is located in Valle de Santiago, state of Guanajuato, Mexico.

## Methodology

### Case Study

The focus is on a typical 4ha crop-based farm with limited resources (CIMMYT farm typology T6[2], 122 farmers) located in Valle de Santiago, state of Guanajuato, in the Bajío region of central Mexico (Fig 1). Elevation of ~1,750m above sea level, dry cool season in Nov-April, wet warm season in Jun-Sep.

### Modelling Approach

We apply *Value-Ag*[1], a framework that combines whole-farm economic modelling, risk and uncertainty at the farm level with adoption and short-cycle impact of an agricultural innovation to estimate its likely value to smallholders (Fig 2).

### Scenario Analysis

All scenarios are rainfed and underpinned by a traditional maize-sorghum (M-S) crop rotation (plus beans, B, in some cases), spring-summer cycle, using maize of mixed criollo/hybrid varieties. Livestock includes an initial herd of 4 cattle (sale, milk). Fodder is purchased on demand. Farm labour is hired on demand. Baseline annual yields for the 10-year period (2010-2019) were sourced from the Government of Mexico - SIAP dataset. Other farm data were sourced from the BEM–MasAgro dataset, farm records, relevant literature and expert assessments.

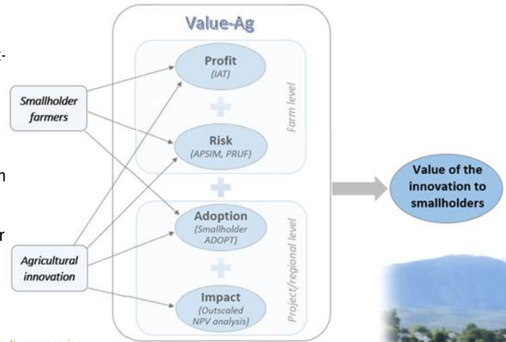


**Fig 2.** *Value-Ag* framework.

**Table 1.** Changes in key modelling parameters between baseline and breakdown of conservation agriculture scenarios, including % yield change over the 10-year period.

| Scenario | Crop rotation | Crop yields (t/ha +% change) | Stubble fate | Seeding | No. of machine passes | Cost of machine hire | No. of herbicide applications | No. of N fert applications |
|---|---|---|---|---|---|---|---|---|
| **1. Baseline** | M-S | 2.7/2.5 | Sold/feed | Conventional | 5 | High | 1 | 2 |
| **2. Conservation Agriculture (CA)** | M-S-B | +35%/+25%/ 1.2+15% | Sold/groundcover/ feed | Direct | 2 | Low | 2 | 1 |
| **3. Crop Diversification (CD)** | M-S-B | +15%/+10%/ 1.2 | Sold/Incorporated/ feed | Conventional | 5 | High | 1 | 1 |
| **4. No Tillage (NT)** | M-S | +5%/+5% | Sold/incorporated | Direct | 2 | Low | 2 | 2 |
| **5. Soil Cover (SC)** | M-S | +15%/+10% | Sold/groundcover/ feed | Direct | 3 | Med | 1 | 2 |
| **6. CD + NT** | M-S-B | +20%/+15%/ 1.2+5% | Sold/incorporated | Direct | 2 | Low | 2 | 1 |
| **7. CD + SC** | M-S-B | +30%/+20%/ 1.2+10% | Sold/groundcover | Direct | 3 | Med | 1 | 1 |
| **8. NT + SC** | M-S | +20%/+15% | Sold/groundcover | Direct | 2 | Low | 2 | 2 |

## Results and Discussion

Compared with the baseline, CA increased individual farm profit by a 10-year average 563% through improvements to crop and livestock production and cost savings in machinery hire, labour and inputs, while reducing financial losses in the poor seasons (e.g. 2015) (Fig 3). Breakdown results for all combinations of CA components (Table 1) suggests that all two-component scenarios (6-8: CD+NT, CD+SC, CD+SC) and NT perform better than the full CA package, while the one-component scenarios CD and SC generate profit gains of ~50% relative to the baseline (Fig 4).


**Fig 3.** Simulated annual farm net profit in the 10-year period of 2010-2019 for the Baseline and Conservation Agriculture (CA) scenarios, and % farm profit gain of CA relative to Baseline.

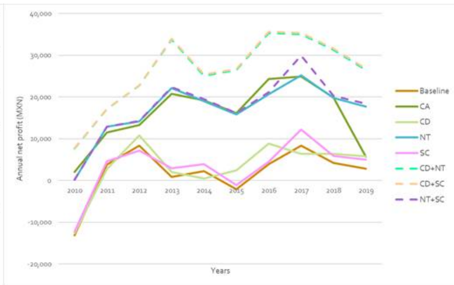


**Fig 4.** Simulated annual farm net profit in the 10-year period of 2010-2019 for the Baseline and all other scenarios analysed in the study.

Nevertheless, workshop participants predicted peak adoption of 94% in 18 years for CA. Combining these outputs within *Value-Ag* resulted in a more accurate estimation of the net value of CA for the targeted 122 farmers (Fig 5). The full set of results for this case study is described in a forthcoming publication.

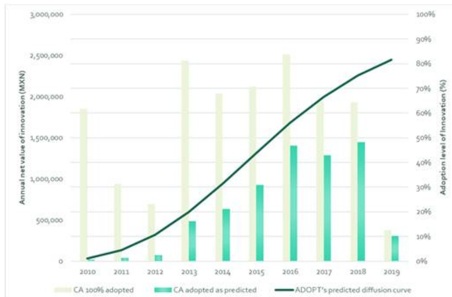


**Fig 5.** Annual net value of CA (scenario 2) for the entire smallholder population (122 farmers) targeted by the CIMMYT project, assuming full adoption (light green bars) and predicted adoption of the full CA package (dark green bars) using *Value-Ag* to combine the economic assessment with a predicted diffusion curve (dark line: 94% adoption in 18 years).

## Conclusion

The CSIRO-CIMMYT collaboration created the opportunity to gain valuable insights for improving farm productivity and profitability as well as reducing risk exposure from a range of CA-based scenarios in a smallholder system in central Mexico, and offered a novel platform to out-scale these changes across the MasAgro project according to predicted adoption outcomes. The study highlights the importance of combining key social and economic drivers at both the farm and region levels for agricultural innovations to be assessed more accurately. Overall, *Value-Ag* outcomes provide clear, consistent and comparable benchmarks across projects/ funders, potentially enhancing investment priorities, project scrutiny, and RDE delivery.

*Agronomy* Special Issue "Farmers' Adoption of Agricultural Innovations and Their Impact"
https://www.mdpi.com/journal/agronomy/special_issues/Agricultural_Innovations
Guest Editors: Marta MONJARDINO, Geoff KUEHNE, Khondoker MOTTALEB

### FOR FURTHER INFORMATION

MARTA MONJARDINO
E MARTA.MONJARDINO@CSIRO.AU
W WWW.CSIRO.AU/

### REFERENCES

[1]**Monjardino M, Kuehne G, Cummins J (2020).** Value-Ag: an integrated model for rapid ex-ante impact evaluation of agricultural innovations in smallholder systems. Experimental Agriculture 56(4), 633–649.
[2]**Zepeda Villarreal EA, Camacho Villa TC, Barba Escoto L and López Ridaura S (2020).** Maize productivity gaps: An explanation based on the heterogeneity of Mexico Central and South farm households. Tropical and Subtropical Agroecosystems 23, #40.

### ACKNOWLEDGEMENTS

This study is the result of a 3-month visiting fellowship at CIMMYT's HQ in Mexico supported by CSIRO Agriculture & Food's Systems Program and CIMMYT's Socioeconomic Program. We thank the collaborative team across four CIMMYT programs for key contributions towards the ongoing case-study development, fully described in an upcoming publication which they co-author. The team includes Santiago López Ridaura, Jelle van Loon, Erick Ortíz Hernandez, Adair Zepeda Villarreal, Juan Burgueño and Ravi Gupta Singh. We are grateful for the support provided by the relevant program directors Olaf Erenstein (SEP), Bruno Gérard (SIP) and Bram Govaerts (DIP).