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Vulnerability assessment and adaptation of dryland agriculture on the Chinese Loess Plateau and Australian Wheatbelt

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Certificate of original authorship

I certify that the work in this thesis has not previously been submitted for a degree nor has it been submitted as part of requirements for a degree except as fully acknowledged within the text.

I also certify that the thesis has been written by me. Any help that I have received in my research work and the preparation of the thesis itself has been acknowledged. In addition, I certify that all information sources and literature used are indicated in the thesis.

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Abstract

Sustainable agricultural production on drylands faces challenges from increasing food demand and climate change. The interrelated issues of production instability, vulnerability to climate change and the need for effective adaptations require a comprehensive and integrated ecological-economic assessment. Accordingly, this thesis examines two key dryland agricultural regions, the Australian Wheatbelt and the Chinese Loess Plateau, to provide new insights and improved approaches for dryland agricultural management.

Decomposition analysis was undertaken to identify the driving forces in growth and instability of Australian wheat production from 1900-2010. Results show that instability of Australian wheat production has not been reduced significantly in the past century. The increasing trend of wheat production was mainly due to sowing area increases whilst the yearly fluctuation of production is mainly caused by variable yields. A focus on yield alone may therefore bias assessments of the vulnerability of agriculture to climate change.

A conceptual framework was developed to assess the agricultural vulnerability of 243 rural counties on the Chinese Loess Plateau. A vulnerability index for each county was calculated from statistical indicators. Within the 49 most vulnerable counties, 42 were characterised by high exposure and sensitivity but low adaptive capacity. The most vulnerable area was found to be located in the central northeast-southwest belt of Loess Plateau.

Upon identifying vulnerable areas, the effectiveness of the regionally significant adaptation, plastic film mulching, on maize growth was assessed in the Loess Plateau. The APSIM model was calibrated and validated using field experiment data, then applied to simulate maize growth during 1961-2010 at Changwu station. Plastic film mulching could significantly increase maize yields by an average of 15.3%, and increase the cumulative probability at mid-range yield levels at Changwu. The advantage was found to be more pronounced in dry years than wet years. Geostatistical analysis was used to extend the modelling across the Loess Plateau to identify areas with climate favourable for adopting plastic film mulching. The central south presented high and stable production while the northwest showed the greatest potential in yield increase and variability reduction.

The multiscale studies concern both developing and developed counties, can be referenced to location-specific information for policy makers and researchers. The principles, frameworks, technologies and tools can be modified and adopted in other dryland regions.

Key words: Dryland, Australian Wheatbelt, Loess Plateau, Climate change, Agricultural production, Vulnerability, Adaptation

Symbols and abbreviations

ABARES	Australian Bureau of Agricultural and Resource Economics and Sciences
ABS	Australian Bureau of Statistics
APSIM	Agricultural Production Systems sIMulator
CSIRO	Commonwealth Scientific and Industrial Research Organisation
ESW	Extractable soil water
FAO	Food and Agriculture Organization of the United Nations
IPCC	Intergovernmental Panel on Climate Change
LAI	Leaf area index
WUE	Water use efficiency
RCP	Representative concentration pathways
UNDP	Office to Combat Desertification and Drought
UNSO	United Nations Sudano-Sahelian Office
$	dollar/s

°C	degrees Celsius
ca.	approximately
e.g.	for example
ha	hectare
kg	kilogram
km	kilometre

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