THE CLIMATE CHANGE ADAPTATION POTENTIAL OF INTEGRATING URBAN AGRICULTURE WITH ARCHITECTURE IN INLAND SOUTH AFRICAN CITIES

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The climate change adaptation potential of integrating urban agriculture with architecture in inland South African cities

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Abstract

In response to the protracted and ineffective international action on the climate change crisis, this study critically considers the potential of building-integrated agriculture (BIA) as retrofitting strategy to improve the climate change adaptation (CCA) capacity of buildings in South African inland cities. Based on a pragmatism paradigm, the study uses a mixed method research design, to evaluate current BIA farms and their efficacy as CCA retrofitting strategies to improve the thermal performance of the local built environment.

The exploratory research is structured in three phases. During the first phase the unused and underutilised spaces of Hatfield, a rapidly changing neighbourhood in Tshwane, South Africa, are mapped and defined in terms of their latent climate change adaptation capability. Secondly, the spatial and technological characteristics of the current BIA industry is surveyed through a series of interviews and observational studies. As the final research phase, a specific BIA farm type, passively controlled non-integrated rooftop greenhouses, is assessed in terms of its reciprocal thermal impact on the built environment.

As outcome, the research findings reveal a land-use form that can contribute to the climate change adaptation response strategies of South African cities on a spatial level. Unfortunately, the design resolution and technological realisation, specifically the prevalent form currently implemented in Johannesburg and Tshwane, adversely affect both farmers and building occupants during overheated periods. As a result, the study advocates developing and testing contextually appropriate technological solutions in the BIA industry.

The study advances the climate change discourse by assessing the performance of BIA farms as constituent entities in networks of small-scaled climate change adaptation projects in resource constrained urban environments.

Keywords: Climate change adaptation, building-integrated agriculture, Tshwane, rooftop greenhouses, unused and underutilised spaces, building performance modelling, urban agriculture.

PREFACE

This thesis developed from several conversations with my supervisor, Professor Chrisna du Plessis, on how to make our cities more sustainable. Thank you for your patience and advice that made this study possible.

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To all the urban farmers that have taken the plunge to challenge the status quo, for the bravery to go where others do not dare, and reminding us of the latent potential surrounding us.

DECLARATION

I, the undersigned author, declare that the applicable research ethics approval has been obtained for the research described in this work and that I have observed the ethical standards required in terms of the University of Pretoria's Code of Ethics for Researchers and the Policy Guidelines for Responsible Research.

This treatise is submitted in fulfilment of part of the requirements for the degree Philosophiae Doctor in Architecture at the University of Pretoria. No part thereof has already been, or is currently being, submitted for any other degree or examination at any other university.

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RESEARCH CONTRIBUTION

Hugo, JM & du Plessis, C. 2017. *A framework for the utilisation of interstitial spaces in South African cities to improve urban climate resilience*. Presented at the Resilience for Development Colloquium, 2017. Johannesburg. 8-10 May 2017. Organised by GRAID, SAPECS, Centre for Complex Systems in Transition, SWEDBIO.

Hugo, JM, du Plessis, C & Van den Dobbelsteen, AAJF. 2018. *Defining urban interstitial space typologies to enable the transformation and improving the climate resilience of South African cities.* Adaptation Futures Conference. 2018. Cape Town. 18 – 21 June 2018. Organised by PROVIA, ACDI, SANBI.

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Hugo, JM. 2019. *Climate Change Adaptation – What is the role of Architecture?* DesignBuilt Expo and conference. 2019. Tshwane. 7-9 October 2019. Organised by PIA.

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Hugo, JM, du Plessis, C & Masenge, A. Retrofitting Southern African cities: a call for appropriate rooftop greenhouse designs as climate adaptation strategy.

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List of Abbreviations

AR5 – IPCC Fifth Assessment report. Published in 2014

BIA – Building-integrated agriculture

°C – Degrees Celsius

CCA – Climate change adaptation

CCM – Climate change mitigation

CO_2 – Carbon dioxide

$CO_{2\ eq}$ – Carbon dioxide equivalent

COT – City of Tshwane

COP – Conference of the Parties

CPUL – Continuous productive urban landscapes

CSIR – Council for Scientific and Industrial Research

FAO – Food and Agriculture Organization of the United Nations

FAO-PM method – Food and Agriculture Organization of the United Nations – Penman-Monteith equation.

FOI – Frequency of incidence

IESve – Integrated Environmental Solutions

IPCC – Intergovernmental Panel on Climate Change

GIS – Geographic information system

GHG – Greenhouse gas

K – Kelvin

NDC – National determined contribution

NFT – Nutrient film technique

p – p-value

PSI – Potential space impact

PPM – Parts per million

RCP – Representative concentration pathway

RH – Relative humidity

RTG – Rooftop greenhouses

SD – Standard deviation

SPLUMA – Spatial planning and land use management act 16 of 2013 (South Africa)

T_a – Ambient temperature

T_g – Globe temperature

UA – Urban Agriculture

UP – University of Pretoria (South Africa)

ZF – Zero-acreage farming