Rwanda's Agricultural Transformation Revisited: Stagnating Food Production, Systematic Overestimation, and a Flawed Performance Contract System

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Abstract

Sustained productivity growth in the agricultural sector is a key component of a country's path out of poverty. The quantitative development of Rwanda's agriculture in recent years has been widely regarded as a success story and as further evidence for the effectiveness of its government to bring about sustained socio-economic progress. However, simple statistical analysis of publicly available data shows that food crop production volumes and yields have actually stagnated over the last fifteen years. Moreover, agricultural output was significantly overestimated from 2008-2013 and then silently corrected downwards in Rwandan and international datasets. As a result, the country's economic growth numbers are very likely inflated as well. After presenting substantive evidence for these claims, this paper discusses three issues arising from them. First, it argues that yield-raising effects of massive mineral fertiliser application and other 'Green Revolution' technologies were offset by the enormous disruption resulting from the government's rigorously enforced agricultural reform programme. Second, it finds that massive food crop production overestimation likely proliferated due to a flawed performance-based governance system that incentivised bureaucrats and farmers to tweak the numbers instead of compelling them to achieve actual results. Even more, this inflation prevented early detection of agricultural stagnation and consequently also the required adaptation of agricultural policy. Third, the exceptional 'brand-building' capabilities of the Rwandan ruling elite led to the preservation of its false reputation of having achieved skyrocketing yield growth. As a silver lining, a few recently revised reform components point to the possibility of an eventually more successful agricultural transformation, whose chances might hinge on the government's ability to allow more discretion of bureaucrats and more inclusion of local knowledge.

Keywords: Rwanda; agricultural transformation; agricultural statistics; performance contracts; state effectiveness.

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1. Introduction

Agricultural transformation is widely seen as a necessary but not sufficient part of economic development (Johnston and Mellor 1961; World Bank 2008). Historically, fundamental agricultural transformations have been early and central elements in the development of both early industrialisers in the global North and 20th century success stories in East Asia. For example, England becoming the first industrialised nation in the world was pre-dated by a productivity explosion in its agriculture (Apostolides et al. 2008) and a revolution of its land ownership structure (Wood 2002). Similarly, Taiwan's spectacular post-War industrialisation was made possible by profound land reforms under Japanese colonization (Kohli 2004) and a policy and institutional structure that compelled agricultural productivity growth (Amsden 1979). However, such social transformations are complex (Khan 2012) and simplistic policies trying to impose rapid change from above can lead to costly failures, for instance during the Great Leap Forward in China (Li and Yang 2005) and the 1970s villagization programme in Tanzania (Scott 1998).

In economic terms, agricultural transformation can be defined as sustained agricultural productivity growth over two-three decades accompanied by rural income increases for a majority of the population (Whitfield et al. 2015:42). Conceptually, it may be structured in two distinct yet closely interrelated aspects: the technological 'Green Revolution' part (application of mineral fertiliser and improved seeds, mechanisation, irrigation, etc.) and the political economy (government efforts to initiate and implement transformative policies including land reform). In practice, the two components go hand in hand and governments have to master both to achieve sustained agricultural development (Hazell 2009; Tsakok 2011).

Regarding technological factors, a recent major study with a sample of over 70 developing and emerging countries from 1961-2000 found that fertiliser application is the single most important determinant to explain the rise of cereal yields (McArthur and McCord 2017). The two other significant factors, which were much smaller in size, were precipitation levels and improved seeds, while all other variables were found to be insignificant. However, other components of agricultural modernisation, such as the expansion of irrigation and mechanisation, country-specific agricultural research, the provision of rural infrastructure (e.g. feeder roads and storage facilities), and quality extension services are widely seen as further enabling factors to substantially raise yields (Alaerts 2020; Chang 2009; Diao, Cossar, et al. 2014; Fuglie and Rada 2016). Moreover, the organisation of farming and land ownership (e.g. smallholders as proprietors or as tenants, contract farming, large-scale capitalists), and broader political economy and governance aspects often have strong impacts and demonstrate the complexity of sustained agricultural development (Deininger, Hilhorst, and Songwe 2014; Holden and Otsuka 2014; Jayne, Chamberlin, and Headey 2014). Finally, the preferences and livelihoods of smallholder farmers, who are usually the central subjects addressed by various government measures, can be a decisive force. The meta-condition of poverty

manifests itself in fundamental insecurity (Wood 2003). As a result, peasants, rather than striving to maximize yields and income, are particularly risk-averse and focus on food security (Ansoms 2010; Rapsomanikis 2015). To achieve these goals, crop diversification, intercropping and preferring low-yield drought-resistant crops in favour of those maximizing yields and income have proliferated over decades and centuries (Cervantes-Godoy, Kimura, and Antón 2013; Van Damme, Ansoms, and Baret 2014). The forced abrupt change of such a system might lead to severe production disruption with potentially catastrophic effects on food security and even political stability.

During the Asian Green Revolution 1965-1990, food crop production volumes and yields multiplied, nutrition improved significantly and poverty fell sharply across several Asian countries and regions (Hazell 2009). Beyond this general notion, there remains much discussion and controversy about the effects of Asia's agricultural intensification on inequality (Freebairn 1995), the trade-off between poverty reduction and negative ecological impacts (Biswas 1994; Faeth 1993), as well as injustice during transition processes (Robbins 2012). In contrast, there has been limited transformation in sub-Sahara African agriculture, which is still characterised by "a vast and only slowly changing number of poor smallholders contributing most of agricultural output, […] low yields, limited commercialization, few signs of rapid productivity growth, and population–land ratios that are not declining" (Collier and Dercon 2014:92). However, the trajectories of African countries are obviously heterogeneous (Badiane, Diao, and Jayne 2021). While international organisations have advocated for an African Green Revolution (AfDB 2016; Toenniessen, Adesina, and DeVries 2008; World Bank 2008), critics argue that these aspirations are neoliberal commodification projects (Moseley, Schnurr, and Bezner Kerr 2015) and might well lead to ecological collapse (IPES-Food 2016).

To evaluate whether a particular country's agricultural policies are effective, an obvious analytical starting point is its agricultural statistics. Unfortunately, crop production and yield data in developing countries is often of poor quality (Jerven 2014). Incompatible estimates from different data sources for the same crop and year as well as unrealistic one-year jumps within a time series are common (Carletto, Jolliffe, and Banerjee 2015). Also, non-standardised methods and units provide large space for 'negotiation' of data that can lead to highly distorted numbers. Regularly, a range of competing, mutually exclusive data sources exist, allowing governments and international organisations to 'choose' the most convenient one (Jerven 2014). All this warrants a careful and detailed analysis of different available datasets on agricultural development before drawing conclusions on the success or failure of agricultural reforms.

At its core, this paper conducts such a data analysis for the agricultural sector of Rwanda from 2005-2019, thereby examining the macro-effects of the country's agriculture transformation strategies. To that end, publicly available data from various Rwandan sources and the Food and Agriculture Organisation (FAO) are

used. Simple descriptive statistics methods suffice to reveal compelling data patterns. The data section's merit comes from very cumbersome data compilation and careful cross-examination of a plethora of distinct and partially inconsistent Rwandan and international sources. Besides the obvious scrutinising of all available documents (academic literature, government strategies and reports, analyses of international organisations, and articles of the national and international media), additional evidence was obtained from interviewing two former Rwandan government employees as well as from email correspondence with the FAO statistics department (FAOSTAT) and the Rwandan national statistics institute (NISR). The Rwandan ministry for agriculture (MINAGRI) did not reply to two written inquiries.[1]

The remainder of the paper is structured as follows. Section 2 introduces Rwanda's agrarian sector and illustrates various facets of the country's recent agricultural transformation as well as the evolution of its agricultural statistics system. Section 3 presents Rwandan agricultural production and yield data from 2005-2019 by dissecting both Rwandan and FAO datasets. It shows that overall food crop output stagnated and that there has been significant overestimation of production levels and yields. As a result, Rwanda's (agricultural) gross domestic product (GDP) is also inflated. Section 4 discusses potential explanations for the peculiar data patterns. First, the interdependent effects of the technological and political economy aspects of Rwanda's agricultural transformation strategy on the country's food production output are assessed. Then, the mechanics and politics of data collection are scrutinised to shed light on six years of massive and escalating food crop production overestimation. Finally, aspects of the government's efforts to create and maintain a solid reputation of high agricultural transformation performance are illustrated. Section 5 concludes by considering promising aspects of the country's recent agrarian journey and suggesting that a reform of Rwanda's performance contract system might lead to a more effective and successful agricultural transformation.

2. Rwanda's Agricultural Transformation

In academic scholarship and international development, Rwanda stands out as a country that emerged from the apocalyptic tragedy of the 1994 genocide against the Tutsi to become a paragon of state effectiveness and socio-economic development (Booth and Golooba-Mutebi 2012; Chemouni 2018), while simultaneously

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[1] The two interviewed persons were a former senior manager at MINAGRI responsible for food crop production and a former MINAGRI intern in charge of data compilation from agricultural surveys. Their testimonies as well as the statements from FAOSTAT and NISR are used as evidence in section 4. Three other contacted (former) Rwandan government officials did not reply to written requests. It needs to be admitted here that beyond these sparse occasions, evidence collection and data analysis was mostly conducted without discussing issues with Rwandan organisations or individuals. The author has lived in Rwanda for three years, of which he spent ten months (January-August and October-November 2019) on intensive PhD-related fieldwork, interviewing over one hundred Rwandans working in government, business, and agriculture. However, the particular topic of this paper was not studied during fieldwork, as the author only stumbled upon the peculiar data patterns analysed here after returning home.

maintaining a dismal record on political and human rights (Reyntjens 2013; Straus and Waldorf (eds.) 2011).

Rwanda's exceptional record of almost 8% annual economic growth over the last two decades (and over 5% per capita growth) made it rank in Africa's top three in this time period. However, agriculture still accounts for 24% of the country's national income, with close to 70% of the working age population engaged in it (World Bank Group and Government of Rwanda 2019:221). Almost two thirds of agricultural value comes from food crops. Average annual agricultural growth was reported as 5.4% over the last two decades, of which nearly two thirds were attributed to food crop growth. Virtually all Rwandan farmers are smallholders and engage fully or partially in subsistence agriculture.

There is a consensus in academics that Rwanda has succeeded in substantially raising its total agricultural production volume and that this was largely driven by substantive yield growth. An often-used summary is that between 2007 and 2011 production volumes of cassava, maize and wheat tripled, those of beans doubled, and rice and Irish potato output rose by 30%. This statement appears in lauding (Golooba-Mutebi 2014), agnostic (Harrison 2016) and condemning (Cioffo, Ansoms, and Murison 2016) articles on Rwanda's agricultural policies. Reports of international organisations use very similar formulations (Diao, Bahiigwa, and Pradesha 2014 (IFPRI); IFAD 2013; World Bank 2014). Virtually all other academic works concerned with post-genocide Rwandan agriculture at least implicitly acknowledge the general notion of the country's agrarian macro-level success. Donors increased their contributions based on these numbers (Harrison 2016) and Agnes Kalibata, Rwanda's agriculture minister from 2008-2014, has been lauded as the responsible mastermind and received several international prizes for her achievements (AFP 2019; NAS 2019).

Agricultural activity is coordinated by the Ministry for Agriculture and Animal Husbandry (MINAGRI) and its two main agencies, the Rwanda Agriculture Board (RAB) and the National Agriculture and Export Board (NAEB). Additionally, the National Institute for Statistics of Rwanda (NISR) commissions agricultural surveys and collects agricultural data. The most important administrative units of local government are Rwanda's 30 districts, which prioritise and organise agricultural activity via their district agronomists and cash crop officers, as well as government-appointed personnel in each of the country's 416 sectors (Chemouni 2014). Cooperatives have been established as rural change agents to eventually grow into capitalistic actors (Harrison 2017). However, they are not grassroots- but government-driven, and so far, both the membership rate and the level of professionalism have been very low (Ansoms et al. 2018). While large-scale agrarian projects have been initiated (Gaynor 2015; RDB 2019), agricultural surveys show that major capitalist farms so far only account for a small share of output and employment (NISR 2019).

Rwanda's agricultural year lasts from September to August. It has two major agricultural seasons: season A, for which planting starts in mid-September (coinciding with the start of the short rain season) and harvesting takes place from mid-December to mid-February, and season B, where sowing commences in March (parallel to the long rain season) and the harvest occurs from early June to mid-July (WFP 2016). In recent years, total production has been slightly higher in season A. Additionally, there is a tiny third season (season C) with harvesting in September that accounts for less than 2% of total production and is therefore often neglected. Both the calendar year and the Rwandan fiscal year (July-June) contain the same season A and B, which makes comparing different data sources easier.

2.1 Government Strategy and Implementation

Rwanda's yield growth is ascribed to its ambitious agrarian reform programme, formulated in its agricultural transformation strategies, currently in its fourth recurrence (MINAGRI 2018b), and guided by the country's overall Vision 2020. The policies follow a technocratic 'Green Revolution' rationale of agricultural intensification, modernisation and commercialisation. Already in 2004, a land tenure regularization process had been initiated that led to both much higher land rights formalisation and a –potentially temporary– increase in land conflicts (Ali, Deininger, and Duponchel 2017; Santos, Fletschner, and Daconto 2014). Over the past years, the main policy regarding agricultural growth has been the Crop Intensification Programme (CIP) that ran from 2007–2020. At its heart was the creation of regional monocropping zones based on agro-climatic conditions (Harrison 2016). For this endeavour, six priority crops were selected: beans, cassava, Irish potatoes, maize, rice, and wheat. The overall goal was to achieve food security and eventually a food surplus for export by increasing food crop production volumes (Kathiresan 2011). This was to be reached largely by substantive yield growth (intensification) via various Green Revolution techniques (see below) but also by increasing cultivated land area (extensification) via the reclaiming of marshland, which was quite successful (Dawson, Martin, and Sikor 2016).[2]

The CIP comprised four pillars: land use consolidation (LUC), provision of inputs, extension services, and improved post-harvest storage. Regarding LUC, farmers were encouraged or compelled to synchronize crop cultivation by switching to the centrally determined priority crop of their region on rearranged adjacent plots to counter the extremely small size of land holdings (0.76 hectares on average, spread over several scattered plots) (Kathiresan 2011). An elaborate input provision system was designed, implemented and adapted over time, in which farmers participating in the CIP and complying with LUC received substantially subsidised mineral fertilisers (Chemouni 2016). Additionally, improved seeds and pesticides were distributed regularly (RAB 2013, 2017). Extension services entailed education and consulting, such as the propagation of good agronomic practices like terracing against erosion

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[2] An additional aspect of Rwanda's agricultural policies revolves around livestock, which is not considered in this paper.

and manure application (MINAGRI 2009b, 2018b) as well as the establishment of plant clinics (Tambo et al. 2020), but also detailed monitoring and strict enforcement of farmers' policy compliance (Ansoms 2009). Logistically, farmer controlling was embedded in the 'decentralized' district-level governance system of performance contracts (locally known as *imihigo*). Given the designation of food crop agriculture as a key development area for almost all of Rwanda's thirty districts, ambitious district-specific objectives were set within this system according to the priorities of the country's agricultural transformation strategy. In particular, annual crop-specific targets for the pooling of acreage as well as for yields within these consolidated areas were formulated in district performance contracts.[3] Additionally, various irrigation and mechanization projects were designed and implemented (MINAGRI 2011), and extensive agricultural research on soil quality and depletion, crop diseases, pesticides, breeding of new varieties adapted to local conditions, etc. was conducted (RAB 2017).

Simultaneously, a rigorous commercialization was pursued via the creation and continuous upgrading of agricultural value chains. Rural market centres were built, farmer membership in cooperatives was encouraged or compelled, these cooperatives were trimmed towards for-profit business planning, and the state oversaw contracting between them and newly constructed private and parastatal agro-processing companies (Harrison 2016). Cooperatives were organised in a four-level system of grassroots cooperatives, crop- and district-based unions, national crop-based federations and one overarching national confederation (MINICOM 2018). Additionally, sector-based savings and credit cooperatives (Imirenge SACCOs) were established nationwide, aiming to financially include rural citizens and encouraging them to open a current account for financial transactions, save money formally, and take up agricultural loans (MINECOFIN 2009). Furthermore, export-oriented cash crops were heavily promoted. These included the transformation of the traditional coffee and tea sector from low-value unprocessed to high-quality processed exporting as well as experimentation with building up various horti-, flori-, and sericulture value chains. In 2019, NAEB launched a highly ambitious high-value export crop strategy, intending to almost double export earnings to 1 billion USD until 2024, centred on high tea and horticulture export growth (NAEB 2019).

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[3] Many district performance contracts can be found online. For example, almost all district imihigo documents since 2015 are available on the Ministry of Finance's website(https://www.minecofin.gov.rw/1/publications/reports?tx_filelist_filelist%5Baction%5D=list&tx_f ilelist_filelist%5Bcontroller%5D=File&tx_filelist_filelist%5Bpath%5D=%2Fuser_upload%2FMinecofin% 2FPublications%2FREPORTS%2FNational_Development_Planning_and_Research%2FIMIHIGO%2 F&cHash=ad46c88d815cc9bd563f53081dafddd4, last accessed on 10 September 2021). Additionally, each district has its own website, usually with several performance contracts uploaded. For instance, until recently, Nyamagabe District had all but one of its district imihigo since 2008 available on its website, which is still accessible via the internet archive *The Wayback Machine* (https://web.archive.org/web/20201027152016/https://nyamagabe.gov.rw/index.php?id=166, last accessed on 10 September 2021).

2.2 Academic Evaluation

Scholars have heavily criticised the rights-denying nature of agrarian change processes in Rwanda and connected it with the ruling elite's more general transformation ideology. And indeed, agricultural policy measures in Rwanda have been designed by the ruling party and implemented by the bureaucracy and local government entities without properly considering the knowledge and preferences of peasants, as confirmed by both farmers (Ansoms 2010; Dawson et al. 2016) and policymakers (Ansoms 2009; Behuria 2020). For example, many peasants have been compelled to cultivate specific crops, to abandon others, and to cease intercropping (Van Damme et al. 2014), to consolidate their land with other farmers (Cioffo et al. 2016), and to form cooperatives in order to maintain access to state-owned wetlands (Bisoka and Ansoms 2020). Some were expropriated without compensation and their lands were used for large government cash crop projects (Ansoms 2013; Huggins 2014).

In more general terms, Rwanda's rural and agrarian strategies fit within the ruling elite's overarching ambition to fundamentally transform the country. The government's approach has been classified as 'high-modernist social engineering' (Scott 1998), defined as an authoritarian state with enormous coercive power using its capable and well-organised bureaucracy to steer a prostrate society into a fully-fledged social and economic modernisation propelled by the ruling elite's ideological faith in the planability of societal progress (Newbury 2011). In particular, the Rwandan government's actions are understood as aiming to make rural space and agriculture 'legible' (ibid.), to create the "exemplary citizen on the exemplary hill" (Ansoms and Cioffo 2016), to surveil the entire country (Purdeková 2011), to contain any form of political dissent (Reyntjens 2004) and to maximise political control in general (Reyntjens 2013). In agriculture, the key technocratic instruments were simplification (massively reducing complexity by regional crop specialisation) and quantification (defining baselines and targets for a large range of indicators). Unsurprisingly, these authors conclude that both the ruling elite's general governance approach and its particular agricultural reforms are not sustainable (Ansoms et al. 2018).

Other authors applying different concepts arrive at deviating conclusions. Booth and Golooba-Mutebi understand the Rwandan state to be a paragon of 'developmental neopatrimonialism', where structural conditions and the elite mindset have freed the country from the 'African modal pattern' of non-developmental clientelism, and which succeeds in using state capitalism to bring about the acquisition of technological capabilities and high economic growth (Booth and Golooba-Mutebi 2012). Their argument applies selected parts of Khan's political settlement framework of assessing a country's power configuration and the ruling elite's ability to centralize economic rents (Khan 2000, 2010). They argue that Rwanda's political economy is also conducive to effecting positive agricultural change (Booth and Golooba-Mutebi 2014). Using Mann's (1984) state power framework, Mann and Berry argue that the

Rwandan ruling elite is pursuing agricultural transformation in the form of deepening rural capitalist relations and expanding the state's infrastructural power as a means to maximise its political control and remain in power. Therefore, in post-genocide Rwanda, the government's political survival and successful economic development go hand in hand (Mann and Berry 2016). Similarly, Harrison considers the negative perspective of the academic majority to be based on an incorrect understanding of how agricultural transformation is bound to take place following historical precedent. He rather describes the dynamic processes as a state-led agrarian capitalist transformation that is both risky and promising (Harrison 2017).[4]

Peer-reviewed in-depth micro-level research has established that –independent of supposed agricultural macro-level output and productivity growth– Rwanda's agricultural reforms have led to severe negative consequences for many smallholder farmers and rural communities all over the country. Dawson and co-authors found that as a result of agricultural policies "subsistence practices were disrupted, poverty exacerbated, local systems of knowledge, trade, and labor were impaired, and land tenure security and autonomy were curtailed" (Dawson et al. 2016:204). Pritchard concluded that "the rapid and forceful implementation of tenure and agricultural policies is unnecessarily undermining the livelihood stability of rural subsistence farmers" (Pritchard 2013:186). Nilsson established that a positive association between land use consolidation and crop yields did not hold for households with landholdings of less than 1 hectare (Nilsson 2019), i.e. 96% of all farms (WFP 2009). Clay and King maintain that "deactivation of local risk management institutions has diminished climate risk management options for most households" and that those without "access to capitals (land, labor, and nonfarm income) […] are pulled deeper into poverty with each successive climatic shock" (Clay and King 2019:1).

2.3 Agricultural Statistics System

To understand the data analysis (section 3) and its discussion (section 4), it is essential to know that two distinct and only loosely connected agricultural data collection systems exist in Rwanda: a constantly evolving agricultural survey system and a local agronomist production estimation system (existing in most developing countries and usually known as 'routine system' (Carletto et al. 2015)). The two systems are illustrated in turn as follows.

After the genocide, the comparatively high-quality pre-civil war agricultural data collection system had been destroyed (Donovan 2008). In the emergency period after 1994, rough harvest estimates were needed to calculate the required food aid (FAO and WFP 1997) and to that end, so-called crop forecasting surveys (at that time known under the French term *enquêtes de prévision des récoltes*) were conducted from 1997 onwards (Nyabyenda and Niyonsaba 2009). While their

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[4] The very different conclusions on the success chances and sustainability of Rwanda's current development path originate to a large extent in a fundamentally different basic understanding of the nature of economic development, i.e. the premises held and theories applied by various scholars. Often, these are not made explicit, thus preventing a profound academic dialogue about existing differences.

methodology was refined over the years and they were later known as crop assessments (CAs), the Rwandan statistics institute highlighted in a 2012 stock-taking exercise and improvement plan that they never amounted to ex-post output estimates but remained "*forecasts* of *potential* production produced *before the end of every season* and carried out principally for food security purposes" (NISR 2012:3, emphases added). However, up to the fiscal year 2013/14, official agricultural statistics were solely based on these biannual CA forecast surveys, even though other complementary and partially more professional and reliable agricultural surveys were carried out over the years.[5] The CAs were eventually discontinued after season 2014B. There is no public information available for the methods of pre-2008 CAs and this missing transparency has been criticised at the time by analysts (Donovan 2008).

The Rwandan government was aware of the poor quality of its statistics at the time and worked diligently on its improvement (MINECOFIN 2002). In late 2005, NISR was established, and from then on, it was jointly responsible for the production of agricultural statistics in collaboration with MINAGRI's statistics department. Authorities realised the need for a large-scale agricultural baseline survey and thus, the National Agricultural Survey (NAS) was carried out in 2008. It was in several regards an important milestone towards the professionalisation of Rwanda's agricultural statistics system. First, it used a sophisticated and representative sampling methodology coming from earlier nationwide general surveys. Second, it used rather professional data collection methods (standardized measurement tapes, spring balances and buckets) and hence arguably produced more accurate evidence than previous surveys. Third, since its results are publicly available, they provide an important reference for the simultaneously conducted crop assessments constituting official numbers. From then on, all post-2008 CAs surveyed a 25% sub-sample of the 10,040 household sample of the NAS (MINAGRI 2009a). However, post-2008 CAs did not use the improved data collection methods but remained with less precise eye estimate approaches (MINAGRI 2009a; NISR 2012).

In NISR's first National Strategy for the Development of Statistics (NSDS) 2009-2014, the need to improve the "forecasting/estimation methodology for crop […] production" (NISR 2009:160) was formulated as the top priority goal for agricultural statistics. Soon afterwards, it was decided to completely overhaul the agricultural data collection system and to set up a modern state-of-the-art statistical framework (NISR 2012). External consultants were hired and they set up a seasonal agricultural survey (SAS) that was initially conducted in season 2013A, became the sole source of official agricultural statistics from the fiscal year 2014/15, and has been carried out in each season ever since with further advancements in 2017 and 2020.

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[5] These included thorough donor-funded biannual household surveys of the Food Security Research Project (FSRP) from 1999-2002, the recurring Integrated Household Living Conditions Survey (EICV I-IV) in 2000, 2005, 2011 and 2013/14, the Light Rural Sector Survey (LRSS) from 2006-2007, and the large 2008 National Agricultural Survey (NAS), intended as a baseline for subsequent crop assessments. A visual overview of the different data collection exercises including their current public availability is provided in appendix 1.

The SAS uses a multiple frame survey design (area and list sampling[6]), which was more professional than in the NAS 2008 (Manzi 2013; NISR 2013). While the survey reports and accompanying documents are very transparent on sampling methods and content of questionnaires, they hardly mention area and yield *measurement* techniques. It can be deduced that area was measured by using precise satellite data. Yield metering was conducted via a mixture of standardised weighing procedures and directly asking farmers.[7] Thus, the SAS still partially relies on farmers' recall. However, surveying occurred immediately after or even during harvesting, thus significantly reducing potential recall biases (Wollburg, Tiberti, and Zezza 2021). Most importantly, splitting data collection in two phases and surveying production results in the second phase during or after the harvest eliminated the likely error in crop assessments resulting from production volume anticipation before harvesting began.[8]

Largely independent of the survey system's evolution, the distinct Rwandan routine system of agricultural data collection carried out by local government representatives and reported to MINAGRI operated in parallel. In Rwanda, where state reach and political control is extreme, this administrative system was rebuilt quickly after the genocide, and a detailed network of district- and sector-level agronomists responsible for both promoting agricultural modernisation and monitoring reform results was established throughout the country. This system was streamlined when performance contracts were introduced on district level in 2006 entailing annual agricultural targets. In 2008, these targets were formulated according to CIP pillars, namely priority crop-specific goals for the pooling of acreage as well as for yields within these consolidated areas. In 2011, annual performance contracts were introduced for ministries and a few years later, joint sector contracts, for example the Joint Agriculture Imihigo signed by the Minister of Agriculture as the lead and several other ministers and district mayors, were added. Overarching annual objectives are taken from national strategy documents and more detailed targets are negotiated between everyone involved. While initial baselines came from actual values, those of

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[6] Area stratification resulted in ten non-overlapping land-use strata, of which three (intensive hillside cropland, intensive marshland cropland, and extensive cropland; together accounting for 70.5% of total stratified land), were used for sampling. Sample selection was done in two stages, resulting in 327 selected segments distributed all over the country. The list sampling was complementary to the area sampling and enumerated all large-scale farms (LSF). Largeholder farmers were defined as cultivating at least 10 ha of cropland or availing of a certain number of livestock (NISR 2013:3). In total, there existed 446 of them engaged in crop farming in season 2013A. (The SAS depiction in this footnote uses numbers of the 2013 SAS (NISR 2013). In subsequent years, they changed only moderately.)

[7] Crop cutting, the gold standard of yield measurement, was tested in 2017, but never introduced on a larger scale.

[8] In phase I of both seasons, all small-scale farmers within every selected segment (amounting to about 15,000) and all existing crop-cultivating largeholder farmers were identified and interviewed. The data collected concerned demographic and social characteristics as well as crop area, planted crops and used inputs. In phase II, 25% of largeholder farmers with cropland as well as around 1,800-1900 small-scale peasants were sampled for questioning. In this phase, data on crop yields and production was collected.

subsequent years did not represent past achievements but targets of the previous year. Thus, performance contract documents usually do not contain any actual values, only past, present and future targets. Actually achieved results of districts and ministries are submitted in publicly unavailable imihigo reports to the Ministry of Finance and Economic Planning (MINECOFIN). However, realised values of joint sector imihigo are publicly available in so-called Backward-looking Joint Sector Review Reports (BLJSRRs) compiled by responsible lead ministries. To sum up, in parallel to the evolving agricultural survey system that provided data for official statistics, a second independent system of decentralized agricultural data collection was in place, in which local agronomists reported to what degree annual imihigo targets had been achieved. The system's documented vulnerability to data tweaking as well as its interaction with the agricultural survey system is discussed in section 4.2.

The switch of the source of official agricultural statistics from crop assessments until 2013/14 to seasonal agricultural surveys from 2014/15 led to a significant break in the Rwandan agricultural data time series. Looking closely at the patterns reveals a number of peculiar inconsistencies that raise strong doubts over the prevailing narrative of Rwanda's exponential agricultural production and yield growth during the turn of the 2010 decade. The only document (of any kind) that could be found studying Rwandan agricultural data in detail was an academic article by Desiere, Staelens, and D'Haese. They compared Rwanda's official crop yield data from the FAOSTAT's database (coming from the country's crop assessments) with two disparate Rwandan sources (the initial SAS from 2013 and the two household surveys EICV II and III) between 2006 and 2013 and found remarkable discrepancies, letting them conclude that "[official yield] numbers in Rwanda are too optimistic and may even be plainly wrong" (Desiere et al. 2016:1384). While their study is recapitulated in the synthesis article of Ansoms et al. (2018), in which Desiere is a co-author, more recent evidence (i.e. any data from later seasonal agricultural surveys) is not included. In fact, not a single academic study, report, or other analysis could be identified via in-depth Internet searches that analyses Rwandan food crop statistics over the time series break 2013-2015.

3. Data Analysis

Examining Rwanda's agricultural statistics up to 2019, this section offers substantive evidence for four claims about the evolution of Rwandan food crop production and yields over the last fifteen years. First, according to all available data sources, Rwandan food crop production and yields stagnated between 2005 and 2018, a finding clearly at odds with the prevailing consensus (3.1). Second, Rwanda massively overestimated its agricultural production and yields from 2008-2013, a finding not discussed elsewhere. This claim is investigated by firstly scrutinising Rwandan data sources and dissecting both the strong rise (2007-2013) and the massive drop (2013-2014) of food production levels (3.2), secondly comparing FAO and Rwandan statistics to identify the origins of the unusual discrepancies between

the two sources (3.3), and thirdly analysing individual crop data to corroborate the findings (3.4). These sub-sections conclude that neither Rwandan nor FAO data is reliable. Third, the dismantling of agricultural production data demonstrates that Rwanda's GDP is probably overreported by several percentage points (3.5). Fourth, district-level food crop production data as reported in performance contracts was similarly overestimated from 2008-2013, and –in contrast to official statistics– output volumes in the national performance monitoring system remained on strongly inflated levels until at least 2018, which demonstrates the ineffectiveness of imihigo contracts in the agricultural domain (3.6). Potential explanations for these findings are explored in section 4.

3.1 Food Crop Production Volume and Yield

FAO data on Rwandan food production and yields between 2005 and 2018 paints a peculiar picture (figure 1a). Production volume increased by 33% from 2007-2013, only to reverse back to 2007 levels in subsequent years. For yields, the trend looks even worse: food crop productivity jumped by 33% in only three years (2007-2010), stayed on this level until 2013, and then slowly deteriorated to values 17% *below* initial levels in 2018. If considering Rwandan data sources[9], a similar but significantly more extreme trend appears (figure 1b). Production levels (yields) rose by over 70% (50%) from 2007 to 2013 and then crashed to a level 20% (33%) below 2007
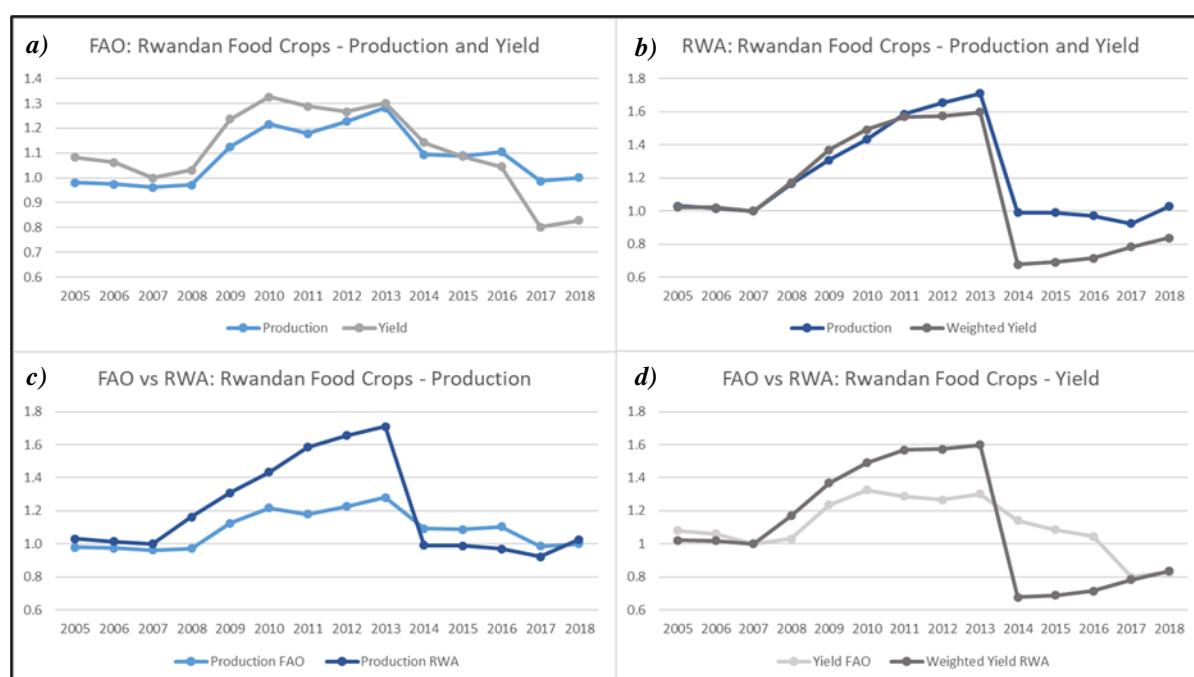

Figure 1: Rwandan food crop production and yields according to FAO and Rwandan data (indexed to 2007 Rwandan data)

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[9] As a result of the rapidly evolving statistics system in Rwanda, there is no single publicly available Rwandan data source that covers the entire period 2005-2018. The data analysis at hand mostly uses numbers from annual reports of MINAGRI (reproducing official crop assessment data) and seasonal agricultural surveys of NISR. For earlier years, data is taken from statistical yearbooks and a report from the Rwanda Environment Management Authority (REMA). In general, for most years, statistics from more than one Rwandan source exist, and in the course of this analysis, they have been thoroughly cross-checked regarding internal consistency. Therefore, the herein used numbers robustly represent Rwandan sources. A full list of all studied data sources can be found in appendix 2.

volumes in 2014. From there, they slowly rose again to almost reach pre-reform levels in 2018. The FAO and Rwandan time series for food crop production and yields significantly differ, which is uncommon (see section 3.3), but they do converge in recent years (figures 1c and 1d). According to both FAO and Rwandan sources, Rwandan food crop production and yields did not increase permanently but rather exhibited a hump from 2007-2014. Most importantly, in both datasets, production and yield levels in 2018 are at or below 2007 levels, constituting stagnation.[10] This result is clearly at odds with the consensus in the literature as summarised above.[11]

3.2 Overestimation 2008-2014

While Rwandan food crop production data from 2000-2007 is likely of rather poor quality (as discussed in section 2.3), it is internally consistent and the FAO has adopted all production numbers of these years without changes. Data inconsistencies between different publicly available Rwandan sources emerge for the first time in 2008 (figure 2), when NISR conducted the NAS. This survey estimated production levels for 2008 to have *decreased* by 22% from 2007. In parallel, MINAGRI continued to conduct its CAs in 2008 and reported a 16% *increase* from 2007. As both the sampling and the measurement methods of the NAS were much more sophisticated than those of the early CAs (see section 2.3), it is highly likely that the low NAS estimate was more accurate than the high CA result. The 2008 NAS numbers might therefore be understood as a correction of already inflated food crop numbers of 2007 and before.

From 2009-2014, MINAGRI continued to conduct CAs, which exhibited significant annual growth in production levels (henceforth labelled high-growth path). All government documents, e.g. all annual reports (AR) from MINAGRI from 2008-2013/14, the statistical yearbooks from 2008-2013, as well as other strategies and reports use these high-growth path numbers.[12] The lower production level measured by the NAS in 2008 was picked up again by the first seasonal agricultural survey in 2013, and subsequent SAS from 2014-2019 were in line with it (henceforth labelled low-growth path).

In its AR 2013/14, MINAGRI still reported the high-growth path CA numbers (the last two orange data points), while the SAS 2013 and SAS 2014 conducted by NISR already reported much lower production levels (the second and third blue data

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[10] NISR dismissed this conclusion referring to official Rwandan GDP data as evidence for growing food crop production (email correspondence with senior NISR employee, 22 May 2021). However, strongly growing food crop GDP data rather points to its unreliability than being proper evidence for high food crop production growth (see section 3.5).

[11] It might appear hard to believe that this simple insight easily visible from readily available FAO data has not been discussed anywhere. The significant gap in academic work might be attributed to a comparative scarcity of Rwanda research (even though it is much more studied than many other African countries) and/or to a different academic focus. However, the complete lack of mentioning this major issue in any report of an international organisation (FAO, World Bank, IMF etc.) is peculiar (see section 4.3).

[12] It was already shown above that both academic articles and reports of international organisations adopted these findings as well.

points). MINAGRI's AR 2014/15 then started to source its data from the SAS, such that numbers for both of its reported years were then much lower. This means that for the year 2014, the two corresponding MINAGRI ARs 2013/14 and 2014/15 document fundamentally different numbers for identical items. Unfortunately, no document mentions or explains the change in methodology or the jumps in production levels. For the purpose of this paper, high 2013 numbers and low 2014 numbers have been used, making the sharp drop 'occur' from 2013-2014. Alternatively, it would appear in the data from 2014-2015, but it is clear that a real one-time drop did not happen in this magnitude or at all. Rather, the more sophisticated survey methodology showed that real production and yield numbers were much lower than reported in the crop assessments. However, Rwanda has not adjusted its overestimated 2008-2013 agricultural data so far.[13]
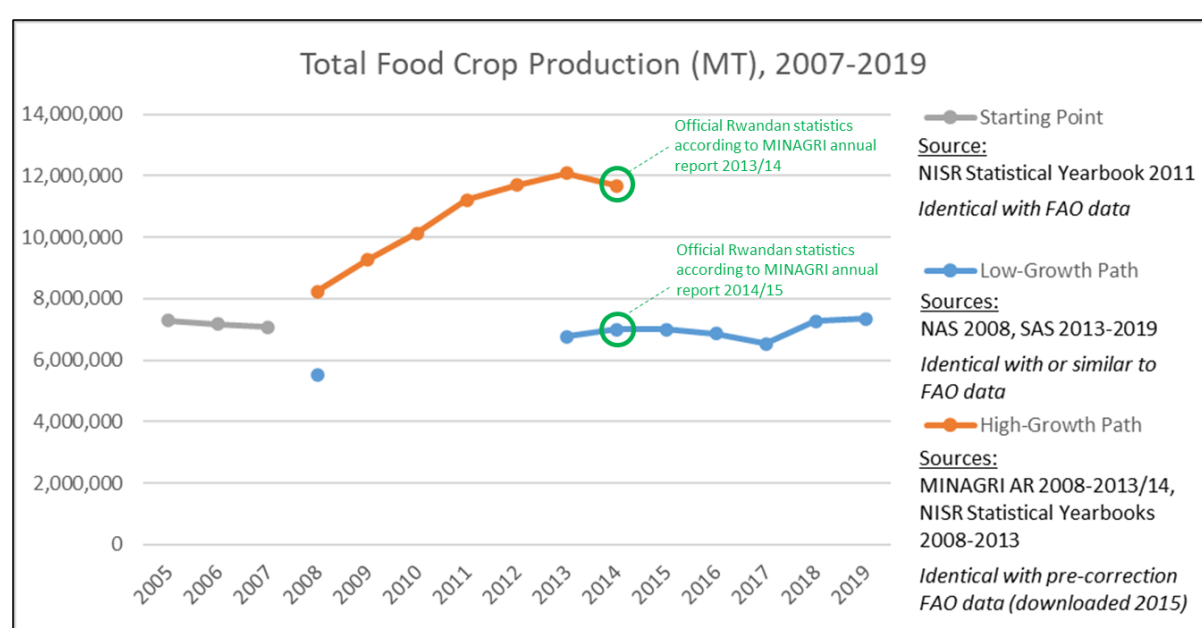

Figure 2: Divergence of low-growth and high-growth paths in Rwandan food crop production statistics

The analysis at hand established that even pre-2008 reports might have suffered from a fair degree of overestimation, as revealed by the NAS 2008. If taking the still shaky[14] NAS 2008 production estimates as a base, food crop production actually *increased* by 29% from 2008-2019, constituting an average annual growth rate of 2.6%. According to this calculation, Rwanda's agricultural reform would at least have produced mediocre output growth. However, a transformational outcome of skyrocketing yield growth, which is still considered an established fact by academic and international community consensus, can be ruled out.

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[13] NISR stated that they „advise to use the 2012 onward level of production data for the concerned crops [i.e. from the SAS 2013] and adjust the series backward to adjust the overestimation in previous years" (email correspondence with senior NISR employee, 22 May 2021). However, they do not do that in any document.

[14] The survey itself states that it did not report yields at all because their measurement turned out to be too unreliable (NISR 2008:19).

3.3 Differences between FAO and Rwandan Data

Discrepancies between FAO and country data is unusual, as the FAO gets its numbers by sending annual questionnaires to country governments asking for production and area data of each crop and then calculates the resulting yield. If data is missing, the FAO imputes these values using an ensemble approach (FAO 2016). However, it does not have a mandate to assess data validity (Desiere et al. 2016).

Initially, the FAO adopted Rwanda's high-growth food crop data from 2008-2014. In their comparative analysis, Desiere et al. (2016) used this original FAO data (which was identical to official Rwandan data). However, as confirmed by the FAO statistics department, their interaction with NISR revealed the 2014 break in Rwanda's agricultural time series due to its updated survey methodology (email correspondence with FAO employee, 24 June 2020). This is why, at some point in time between early 2015 and late 2019, the FAO –based on Rwanda's advice– significantly decreased the country's production and yield data of three food crops from 2008-2013 (table 1), thus leading to significant differences between FAO and country data.[15] For cassava, the subtracted amounts lay between almost exactly 1 million (m) metric tonnes (MT) in 2008 and almost exactly 2m MT in 2012 and 2013. For Irish potatoes, 1m MT were subtracted in each of the years 2011-2013. Wheat production levels were corrected downwards by exactly 90% from 2008-2013.[16] However, none of the other ten crops listed individually each year by Rwandan

Cassava Production (MT)	2007	2008	2009	2010	2011	2012	2013	2014
Rwandan data	779,414	1,681,823	2,019,741	2,377,213	2,579,399	2,716,421	2,948,121	900,227
FAO data (downloaded 10/02/2015)	779,414	1,681,823	2,019,741	2,377,213	2,579,000	2,716,421	2,948,121	---
FAO data (downloaded 13/12/2019)	779,414	681,800	819,700	977,200	979,000	716,400	948,100	900,227
Difference b/w FAO datasets	0	1,000,023	1,200,041	1,400,013	1,600,000	2,000,021	2,000,021	
FAO Source (13/12/2019)	Official data	FAO estimate						Official data
Irish Potato Production (MT)	2007	2008	2009	2010	2011	2012	2013	2014
Rwandan data	967,283	1,161,943	1,289,623	1,789,404	2,171,517	2,337,706	2,240,715	719,006
FAO data (downloaded 10/02/2015)	967,283	1,161,943	1,289,623	1,789,404	2,171,517	2,337,706	2,240,715	---
FAO data (downloaded 13/12/2019)	967,283	1,161,943	1,289,623	1,789,404	1,171,500	1,337,700	1,240,700	719,006
Difference b/w FAO datasets	0	0	0	0	1,000,017	1,000,006	1,000,015	
FAO Source (13/12/2019)	Official data				FAO estimate			Official data
Wheat Production (MT)	2007	2008	2009	2010	2011	2012	2013	2014
Rwandan data	24,195	67,869	72,479	77,193	90,684	75,913	70,129	7,886
FAO data (downloaded 10/02/2015)	24,633	67,869	72,479	77,193	90,684	75,913	70,129	---
FAO data (downloaded 13/12/2019)	24,633	6,700	7,200	7,700	9,000	7,500	7,000	7,886
Difference b/w FAO datasets	0%	90%	90%	90%	90%	90%	90%	
FAO Source (13/12/2019)	Official data	FAO estimate						Official data

Table 1: Difference between FAO and Rwandan data in cassava, Irish potato and wheat production

[15] FAO data is available for download on the FAOSTAT website (http://www.fao.org/faostat/en/#data/QC, last accessed on 10 September 2021). The original FAO dataset on Rwanda containing old numbers already downloaded in February 2015 was gratefully obtained from Sam Desiere, while the updated one was downloaded in December 2019 by the author. The old version is not available anymore and no explanation on the changes made could be found on the website or in the dataset. The only note that a change has occurred was that the data source for some crops and years was 'FAO estimate' instead of 'Official data'. Figure 1 used the updated FAO data.

[16] According to correspondence between NISR and FAOSTAT, the wheat production overestimation in Rwandan data originated from a digit error (email correspondence with FAO employee, 24 June 2020). While this is highly doubtful (see section 4.2), it is remarkable that a significant part of Rwanda's reputation of agricultural success is supposedly based on a typographical mistake.

sources were changed. According to the FAO, these corrections allowed them to link the pre-2014 and post-2014 Rwandan agricultural time series (email correspondence with FAO employee, 24 June 2020). Moreover, this significant downwards adaption of Rwanda's agricultural production data confirmed Desiere et al.'s (2016) conclusion about pre-correction FAO data being much too high.

3.4 Development of Individual Crops

To assess whether FAO data was made sufficiently reliable by manually correcting production levels of cassava, Irish potatoes, and wheat downwards, production statistics of four other important crops are considered. These are the remaining three priority crops rice, beans, and maize, as well as bananas, which are grown in large quantities in Rwanda. Together, these seven crops accounted for 96% of the rise and 88% of the fall in Rwandan data during the period in question.[17] The production volume patterns of the four selected crops reveal two distinct patterns (figure 3). For rice and beans, annual volumes grew moderately and continuously, and FAO and Rwandan data is almost identical. Consequently, there is no evidence of production overestimation for these two crops. This looks entirely different for maize and banana production. For both crops, there is a massive drop in production levels within one or two years in both datasets, exhibiting the same pattern as identified in overall food crop production. In Rwandan data, maize production fell by 47% from 2013-2014, while a two-year drop (2013-2015) of virtually the same size occurred in FAO data. Regarding bananas, the production level decreased by 44% from 2013-2014 in Rwandan data, while an almost identical abrupt decline occurred in FAO data from 2016-2017. Interestingly, the massive drop in maize production occurred after a fivefold multiplication from 2007-2013, thus ending with a net growth of 314%, whereas the large drop in banana production was only preceded by a minor growth spurt, thus resulting in a net decline of 29%.[18]

These graphs illustrate that Rwandan food crop production overestimation was not limited to the three crops manually corrected by the FAO, but also encompassed maize and banana production. Since the FAO did not retrospectively correct the inflated maize and banana production numbers from 2008-2013 and since taken together their rapid decline constitutes 29% of the total fall in food crop production, this means that the post-correction FAO dataset is not reliable either.

Dissecting the production level data patterns for the most important Rwandan food crops has shown that it cannot be clarified whether there was any overall food crop production growth between 2005 and 2019. Hypothetical real growth was overshadowed by massive overestimation and potential real decline was overshadowed by the massive one-time correction of this overestimation in 2014.

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[17] Sweet potatoes are the only 'large' crop that is omitted here due to space limitation. However, its production output evolution is very similar to the one of beans and does not provide additional insights.

[18] This difference suggests that there might have been different mechanisms at work that led to overestimation of these crops in the first place (see section 4.2 for a discussion).
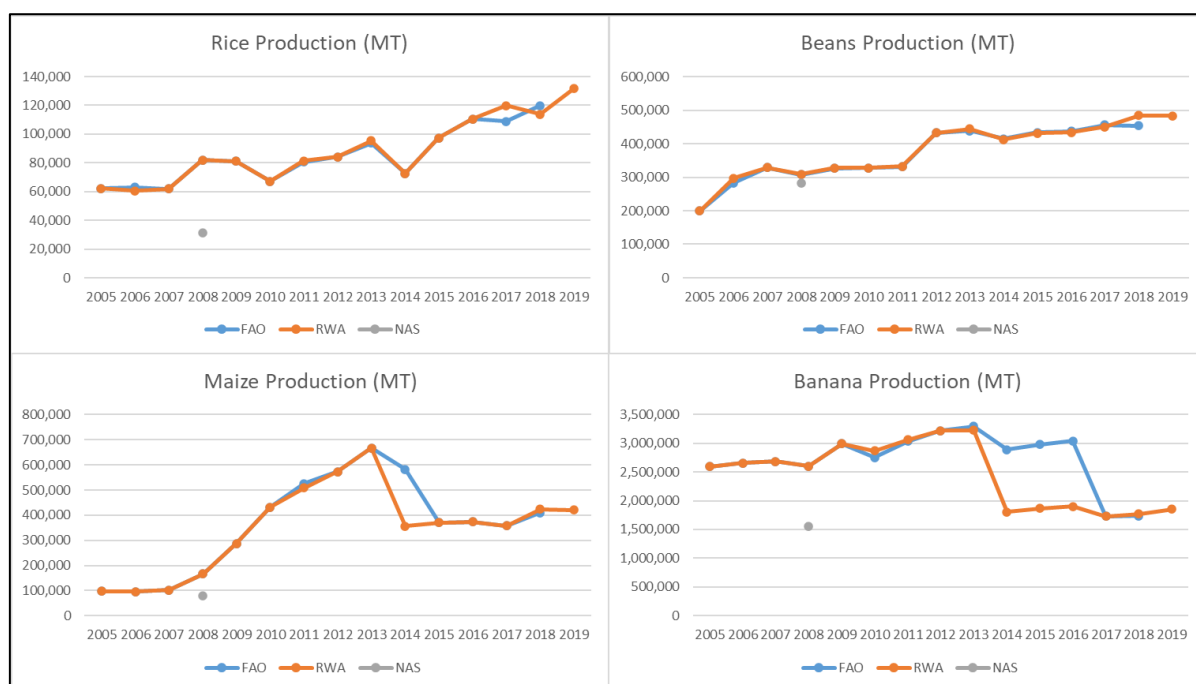
Figure 3: Rwandan production development of rice, beans, maize, and bananas according to FAO and Rwandan Data

3.5 Impact on GDP

In Rwandan national accounts, food crops are listed as a sub-category of agricultural GDP. Depicting food crop GDP development from 2005-2018 against food production shows that the two time series are incompatible (figure 4). While the strong rise in production levels from 2007-2013 (grey and orange lines) corresponds with food crop GDP growth (blue line) during these years, the drop of the former must eventually occur in the latter as well, even if crop production quantities used for calculating GDP somehow differed from the official ones.[19] The conducted analysis does not allow any other conclusion than that Rwanda's food crop GDP (and by definition, also its agricultural and total GDP) has been overreported for several years.[20] Since food crop GDP accounted for 16-19% of overall GDP between 2007 and 2019 and was responsible for 13% of all GDP growth in this period, its manual correction proportionate to food crop production development would have a significant negative effect on previous GDP growth, reducing it by 0.7% per year on average, as well as on GDP in absolute values, decreasing it by 7.1% in 2017. This again would reduce GDP per capita in 2017 from 784 USD to 728 USD.

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[19] Broadly speaking, food crop GDP (as value-added) for a given year can be calculated by multiplying the production volume of each food crop with its price per unit and then subtracting the value of inputs and intermediate goods. When using constant prices and the domestic currency Rwandan Francs (RWF), neither inflation nor exchange rates can have distorted GDP numbers. The value of inputs and intermediate goods rather increased given Rwanda's rising use of mineral fertilisers and other materials. Finally, also relative price changes between crops cannot have occurred in such a way that food crop GDP grew continuously.

[20] NISR rejected this finding, arguing that GDP data compilation, additionally to production data, requires consumption (household, government), trade (export, import) and inventories data (email correspondence with senior NISR employee, 22 May 2021). However, this generic statement about the national accounts system does not relate to the argument brought forward here.
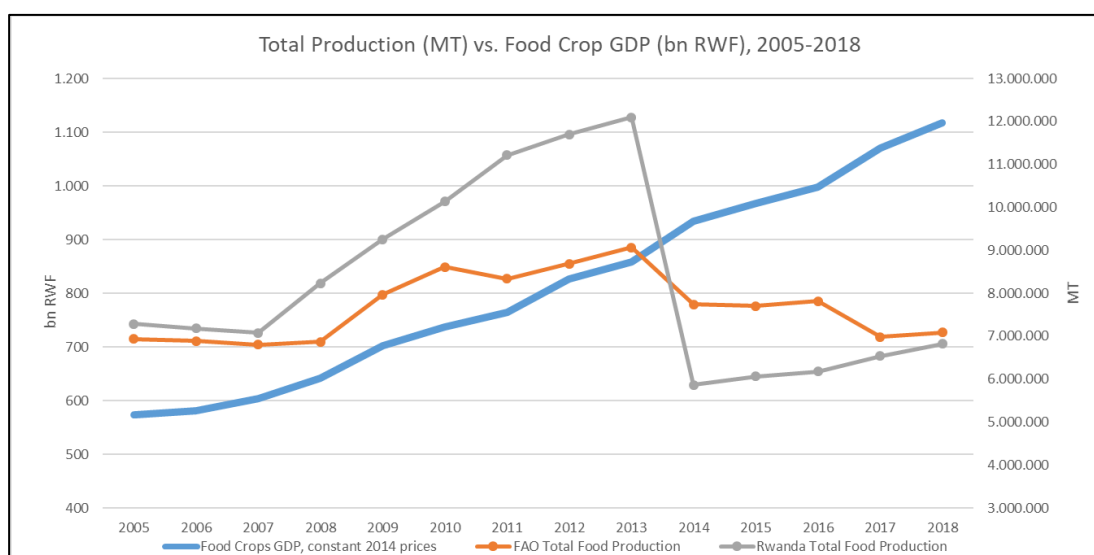
Figure 4: Comparison of Rwandan food crop GDP and total food crop production (2005-2018)

3.6 Performance Contract Data

As illustrated in section 2.3, there exists a second independent system of agricultural data collection by local agronomists in parallel to the agricultural survey system that feeds official statistics. It turns out that during the period of massive overestimation from 2008-2013 the outputs of the two data collection systems were roughly compatible. Assessing the nine publicly available district performance contracts from 2012-2014[21] shows that the annual baselines and targets of consolidated area and yields on these aggregated sites for a few priority crops are approximately in line with the high-growth path of the crop assessment surveys as reported by MINAGRI.[22] This means that the districts' annual performance contracts also strongly overestimated food crop numbers.[23] Direct evidence for this deduction is provided by an RAB evaluation, which found that district agronomists overstated consolidated area by 18.3% in season 2013A (Dusengemungu et al. 2013).

Interestingly, while the reform of the agricultural survey system led to the detection and correction of overestimated numbers from 2014 onwards, district-level and national agriculture performance contracts continued to report vastly overstated numbers. This can be demonstrated by comparing 2018 food crop data from imihigo result reports with official numbers from NISR's seasonal agricultural surveys (table 2). For all six priority crops, area and yield results are much higher in the former than

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[21] For the years 2012-2014, performance contracts of nine districts could be retrieved in January 2020 from their respective websites. The reports are listed along all other studied documents in appendix 2.

[22] Multiplying the consolidated area baselines with the corresponding yield baselines and then extrapolating the resulting production volume to the whole country produces numbers which are equal to or even higher than the inflated output numbers of the MINAGRI annual report 2012/13. See appendix 3 for a more detailed analysis and a table of the actual numbers.

[23] Technically, imihigo contracts contain only baseline and target values, not actually achieved numbers. As explained in section 2.3, even baselines need not necessarily represent past actual values but might be past targets. However, the existing evidence of target values is sufficient in this argument because the Districts Imihigo Evaluation Report 2012-2013 indicates that districts achieved on average 94% of all economic development indicators in that fiscal year (RoR 2013).

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in the latter, resulting in massively overreported production levels (ranging from a 76% excess for rice to a 790% overhang for wheat) in 2018 imihigo data.[24] In total, food crop production for these six crops within consolidated sites is reported to be 192% higher than equivalent food harvests as officially indicated. The simultaneous existence of the two distinct and diverging food crop data systems is also evident in MINAGRI's AR 2017/18, which reproduces the completely incompatible *consolidated* crop area from performance contracts (MINAGRI 2018a:1, table 3) and *total* crop area from the SAS (ibid:6-8, table 9).

2018	Performance Contracts (PCs)			Seas. Agricultural Survey (SAS)			Comparison (PCs-SAS)			Overreporting (%)		
	Consol. Area (ha)	Yield (MT/ha)	Production (MT)	Total Area (ha)	Yield (MT/ha)	Production (MT)	Area (ha)	Yield (MT/ha)	Production (MT)	Area (ha)	Yield (MT/ha)	Production (MT)
Rice	35,867	5.6	200,852	32,780	3.5	113,880	3,087	2.1	86,972	9%	61%	76%
Wheat	52,155	2.3	119,956	12,225	1.1	13,475	39,930	1.2	106,481	327%	109%	790%
Maize	408,586	3.7	1,511,768	296,330	1.4	424,204	112,256	2.3	1,087,564	38%	158%	256%
I. Potatoes	163,525	22.0	3,597,539	111,480	7.5	835,576	52,045	14.5	2,761,963	47%	194%	331%
Cassava	96,575	20.7	1,999,103	92,113	12.2	1,127,199	4,462	8.5	871,904	5%	69%	77%
Beans	767,410	1.7	1,337,442	556,323	0.9	484,729	211,087	0.9	852,713	38%	100%	176%
Total	1,524,116	5.8	8,766,659	1,101,251	2.7	2,999,063	422,865	3.0	5,767,596	38%	111%	192%
Source	MINAGRI AR 17/18	BLJSRR 17/18	---	SAS 2019			---					

Table 2: Difference between reported food crop data of national performance contracts and agricultural surveys

This data provides strong evidence for the notion that –at least in the agricultural domain– Rwanda's performance contract system is ineffective in incentivizing or compelling government organisations (both districts and the ministry for agriculture) to actually achieve transformative development results. To summarize, from 2008-2014, both the agricultural survey and the administrative data collection system produced grossly overestimated food crop estimates. From 2014, the overhaul of the agricultural survey system led to a correction of inflated numbers that were adopted in official statistics. Simultaneously, the detached administrative data collection system propelled by imihigo targets continued to report ever increasing land use consolidation and yield growth within these sites without being seriously questioned. Even more, the completely incompatible results of joint imihigo reports (BLJSRR) and seasonal agricultural surveys were depicted next to each other in official ministry reports.

4. Discussion

The established findings regarding stagnating and overreported food crop production in Rwanda from 2005-2019 raise several questions, of which the following three will be discussed in this section: first, why Rwandan food crop production stagnated in the examined period in the first place (4.1); second, what led to the proliferation and

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[24] Annual imihigo targets were set for consolidated area per priority crop and yields on these sites in Joint Agriculture Performance Contracts. MINAGRI's Backward-Looking Joint Sector Review Report (BLJSRR) 2017/18 contains actual 2018 yield data for the six priority crops and MINAGRI's annual report 2017/18 depicts realised numbers for consolidated acreage, referring to its imihigo report as source. A few earlier BLJSRRs as well as joint agriculture imihigo are publicly available but they all contain incomplete data. However, the data points that do exist display an identical degree of overestimation.

eventual correction of systematic overreporting (4.2); and third, how Rwanda acquired and maintained the false reputation of having achieved skyrocketing food crop production and yield growth (4.3).

4.1 Causes of Stagnant Food Crop Production

Rwanda's either stagnating (official national and FAO statistics) or mediocrely growing (NAS and SAS data) food crop production levels and yields beg the question which factors held the country back. It is not attempted here to quantify the various causes (and this might not be possible given the availability and quality of evidence). Rather, the particular manifestations of prominent technological, environmental, human and political economy factors and their likely impact are depicted, leading to a hypothesis of their aggregate effect.

Technological 'Green Revolution' Factors

According to Rwandan government sources, mineral fertiliser application –the most effective ingredient to raise yields (McArthur and McCord 2017)– increased from 0.5kg/ha in 2000 to 43.5 kg/ha in 2019 (MINAGRI 2019). This trend is consistent with COMTRADE fertiliser import data.[25] Channelling subsidised fertiliser towards four priority food crops (maize, rice, wheat, and Irish potatoes) was a central pillar of Rwanda's CIP (Kathiresan 2011). Chemouni (2016) painstakingly describes how the country's fertiliser distribution system was created and managed quite effectively. Coincidentally, post-correction FAO yield data of the four subsidized crops highly correlates with COMTRADE fertiliser data from 2005-2016 (correlation coefficient of 0.76), which however –given the demonstrated unreliability of the FAO's statistics on Rwanda's food crop yields in that period (see section 3.4)– is spurious, and thus points towards the peril of shallow impact evaluations using a combination of well-fitting datasets.[26] Given the available data, a more sophisticated regression exercise would be futile. In general terms, Rwanda's strong increase of mineral fertiliser import, distribution and application from 2006 would predict high yield growth.

Considering other technological factors, Rwandan sources indicate high growth of plots being subject to irrigation, mechanisation, and the application of improved seeds. However, Rwanda's hilly terrain makes the former two very difficult in large parts of the country. As a result, mechanised tillage farming was practised on only 4.2% of the cultivated area in 2019.[27] Similarly, only 3% of agricultural land was irrigated and improved seeds were used on merely 8.5% of cultivated land (NISR

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[25] In the Rwandan case, annual fertiliser imports can be equated with annual fertiliser application, since no fertiliser manufacturer existed in Rwanda in the examined period, there were virtually no re-exports, and just about all imported fertiliser was also applied in the respective year. Three independent data sources could be identified (COMTRADE, FAO and IFDC). See appendix 4 for a graph depicting their respective developments in relation to food crop yields and showing the volume increase from 2006.

[26] And indeed, using a different time series of fertiliser inputs from IFDC results in a negative correlation coefficient of -0.7.

[27] Dividing the total mechanised land area of 47,060 ha in 2019 (MINAGRI 2019) by total cultivated land of 1.114m ha (NISR 2019).

2019:vii). Good agricultural practices, however, have proliferated widely, exemplified by 72% of farm plots being protected against erosion, and almost 50% of plots being fertilised with manure (ibid.). In conclusion, all technological variables –most importantly mineral fertiliser application– have evolved very favourably over the last one and a half decades. Thus, they cannot explain but contradict stagnant food crop production and yield numbers.

Environmental Factors

Rwanda's mountainous geography means that it has many micro- and niche climates, making technocratic agricultural engineering inherently difficult (Ansoms et al. 2018; Clay 2017). Annual rainfall in Rwanda decreased by approximately 16% from 2005-2017[28] and is often quite erratic. While floods, droughts and even hailstorms occur regularly, a World Bank risk assessment qualified them as not impacting aggregated agricultural production and yields on a national level (Giertz et al. 2015). According to the Rwandan government's disaster reports 2016-2019, around 10,000 ha of crop area are on average destroyed each year due to rainstorms (50%), floods (24%), hailstorms and landslides (e.g. MINEMA 2019).

Pests and diseases are having a much larger negative effect on food crop yields. In some years and regions, crop-specific illnesses can have significant impacts for food security. Moreover, the prevalence of pests and diseases was found to be increasing, potentially exacerbated in the future by more drastic climate change (Giertz et al. 2015). However, in general, diseases and pests occur locally, and therefore, the effects of individual occurrences do not show in national yield data. Rather, their constant presence contributes to yields gaps (ibid.). Acidic and depleted soil is quite common in many Rwandan agro-ecological zones, which is mainly attributed to parent materials and steep slopes (RAB 2021). Soil research, mapping, and fertility management, while on the rise, is considered inadequate (Rushemuka, Bock, and Mowo 2014).

Whereas current climate change models are not able to properly simulate the particular impact of global warming on Rwanda, it has been observed that the country's rainy seasons have become shorter and more intense, leading to both more floods and more droughts and that overall temperature has been increasing rather strongly (Giertz et al. 2015). In sum, Rwanda's environmental situation is understood to be gradually worsening due to, among others, advancing climate change. However, this evolution occurs incrementally and cannot explain yield stagnation in the face of abrupt multiplication of fertiliser application and the proliferation of other Green Revolution technologies, some of which are deployed to counter exactly these austere environmental conditions.

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[28] Annual rainfall in Rwanda was calculated by using terrestrial precipitation time series of Matsuura and Willmott (2018).

Human and Political Economy Factors

For several decades, Rwanda has been facing extreme and increasing land scarcity and population density. Some authors have seen this factor as one of several causes of the 1994 genocide (André and Platteau 1998; Verpoorten 2012; Verwimp 2013). The post-genocide Rwandan government stated that the traditional way of smallholder subsistence agriculture was a dead end and that a fundamental modernisation was required (RoR 2000). Some scholars consider Rwanda's status quo as a neo-Malthusian situation, which justifies the practised vehemence of agrarian reform implementation (Harrison 2016; Van Hoyweghen 1999). Others explicitly warn of using this narrative and bank on the capability of farmers to innovate when induced to do so rather than the government's approach of imposing innovation (Clay 2018; Dawson et al. 2016; Van Damme et al. 2014).

The detailed micro-level evidence described in section 2.2 found that Rwandan top-down agricultural policy-making ignored the reality on the ground, including agronomic conditions and farmer rationales. Even more, revolutionary, abrupt and strict agricultural reform measures created significant upheaval of rural communities and farmers' livelihoods, leading to multidimensional negative effects such as decreased food security, increased landlessness and poverty for a large share of the population. In a nutshell, the reforms strongly increased inequality by driving a wedge in rural communities, enabling a few well-situated farmers to profit from modernisation, while the majority lost out. Additionally, the studies argue that agricultural policies did not properly account for agro-ecological micro-zones, thus exacerbating their other negative effects.

Aggregated Effect of the Determinants

Section 3 has elaborated in detail that national food crop production levels and yields either stagnated or at most grew very moderately from 2005-2019. Given the almost exemplary proliferation of Green Revolution technologies, the aggregate of all evidence implies that the turmoil created by the radical reconfiguration of agricultural practices from 2008 has been so high that even macro-level performance was affected such that the presumably large yield-driving effects of mineral fertilizer application and other modernisation techniques were offset by the yield- and production-depressing effects of severe systematic disruption of regional monocropping and other ad-hoc changes.

From a purely technocratic view, it would be a mystery why Rwanda's food production levels and yields stagnated (or only grew very moderately) over the last fifteen years, despite the country's ambitious agricultural transformation programme and its high technocratic capabilities and state effectiveness. However, with the caveat that quantifying any determinant was not possible, taking into account abundant and consistent micro-level evidence of disruptive change leads to a plausible explanation of food crop production stagnation on national level.

4.2 Proliferation and Eventual Correction of Systematic Overestimation

It is well-known that agricultural statistics in developing countries are often of poor quality (Jerven 2014). Depending on the employed data collection methodology (and after assuming a proper sampling method), several biases might be at work.[29] However, this section does not assess or explain general reporting errors and biases in Rwanda's food crop statistics system that existed already before 2008 and might or might not have been eradicated by the introduction of the SAS. Rather, the relevant question is why and how the time- and crop-specific massive production and yield overestimation from 2008-2014 did occur. In other words, there must have been reasons for the strongly rising food crop production numbers in these years (irrespective of general biases and errors applying throughout the years), when in fact actual production was (almost) stagnating.

Possible Explanations for Overreporting

The data patterns presented in section 3 in combination with the information about the data collection systems and their methodologies illustrated in section 2.3 essentially leave two possible explanations for overreporting. Either farmers reported ever increasing area, yield and/or production data to crop assessment field enumerators while most numbers were in fact stagnating, or crop assessment *report* data did not solely come from crop assessment *surveys* but was amended upwards from MINAGRI's administrative reporting system of local agronomists, and then, *that amended data* constituted the official statistics. A further theoretical possibility would be that the crop assessment report data was deliberately fabricated, i.e. significantly pushed upwards. While such bland manipulation is not unheard of in post-genocide Rwanda[30], there is no evidence for that scenario. Even more, it appears to be quite

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[29] Often agricultural surveys rely on farmer recall regarding the harvested amount of the last season or year. While this approach appears to exhibit no significant bias in either direction (Beegle, Carletto, and Himelein 2012), its precision unsurprisingly decreases with time elapsed since harvesting. More specifically, peasants systematically underestimate area and overestimate production when surveyed several months late (Wollburg, Tiberti, and Zezza 2021). When farmers are asked for their *expected* harvests beforehand (as was done in Rwanda's CAs), different, country-specific biases might be at play. Additionally, there is evidence that farmer overreporting is particularly large, if farms are small (Desiere and Jolliffe 2018; Gourlay, Kilic, and Lobell 2019), which is the case for almost all Rwandan farms. Furthermore, the production of some crops (e.g. high-value cereals) is much easier to measure than that of others such as cassava and bananas (Carletto, Jolliffe, and Banerjee 2015), which are the two most popular crops in Rwanda regarding production volume. In particular, when cassava ripens, it is often stored in the ground for several months and only harvested immediately before consumption or selling. It is only fully harvested in times of need. Banana yields are hard to measure because they are a perennial crop. Since 2018, Rwandan SAS have estimated both cultivated and harvested area for all crops, which are identical for most crops but differ widely for cassava and bananas (NISR 2019). Finally, different incentives might exist for peasants to deliberately over- or underreport their land area, production level or yields. Rwanda's 2012 analysis of its agricultural statistics system mentioned underreporting incentives arising from farmers selling their harvest informally and overreporting incentives connected to subsidy provision (NISR 2012).

[30] Reyntjens (2013:45, 54) showed how Rwandan 2008 Parliamentary and 2010 Presidential election results were fabricated.

unrealistic, as such a fabrication would require the manual change of thousands of individual crop- and district-specific production, yield, and area data points.[31]

Examining the likelihood of the two outlined possibilities, there is only scarce written evidence regarding the compilation of crop assessment data (i.e. official agricultural statistics) from 2008-2014. Of the fourteen undertaken crop assessment surveys from season 2008A to season 2014B, only four corresponding reports (season 2009B, 2010A, 2010B and 2012A) could be found online. According to all of them, sampling occurred by making use of the NAS sampling methodology and surveying a 25% sub-sample (e.g. MINAGRI 2009a). Moreover, the 2012A crop assessment explicitly states that the *reported data* (which is identical to official statistics) is only based on the *surveyed sample* (MINAGRI 2012). Furthermore, both interviewed former MINAGRI employees confirmed this approach. The former intern in the MINAGRI statistics department during the 2008-2013 period was responsible for the compilation of crop assessment survey data of a few districts into provincial aggregates. They confirmed that they received the original data collection sheets from field enumerators and transferred and added up the microdata in specific spreadsheets. The former MINAGRI senior manager, when asked, explicitly stated that local administrative agricultural data and crop assessment survey data (i.e. the two distinct data collection systems) were not put together and that official statistics were only based on survey results. While acknowledging that experienced Rwanda researchers note that the country has "a cultural environment in which concealing or distorting the truth are traditionally regarded as both a virtue and an art" (Lemarchand 1970 as cited in: Jones 2014:12), it seems unlikely that the evidence presented above is entirely distorted to conceal a broadly conceived effort of amalgamating crop assessment survey and administrative agronomist data or even complete data manipulation. As a result, these scenarios are dismissed as explanations for massive overreporting.

Two Channels of Farmer Overreporting

This leaves the possibility of the existence of a particular mechanism that led farmers to accidentally overestimate or deliberately overreport their seasonal food crop production on a massive and annually accumulating scale to field enumerators conducting interviews for the biannual crop assessment surveys. There are two (potentially synergistic) channels how this could have proliferated. The first comes from the general political economy of post-genocide Rwanda. As described above, the Rwandan ruling elite has very ambitious plans for the complete reconfiguration of

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[31] Crop- and district-specific production microdata of the crop assessments 2007-2009 could be retrieved by using the internet archive *The Wayback Machine* (https://web.archive.org/web/20120513124226/http://www.countrystat.org/rwa/cont/pxwebquery/ma/1 84spd311/en/vType/quick, last accessed 10 September 2021). This data fit official aggregated crop statistics quite well. In particular, while season 2007A data was quite off and rice production data deviated for later seasons as well, all other individual crop data added up from all thirty districts fit official national statistics almost perfectly. As a consequence, a deliberate manipulation would have not just required the adaptation of national level data, but of 390 (30 districts × 13 individual crops) data points per season.

rural space and has implemented several far-reaching policies, such as a rural resettling programme (villagization or *umudugugu*) (Newbury 2011) and the introduction of performance contracts that in theory even branch out to the level of individual households (Huggins 2014). Peasants, who are widely affected by various government actions that have increased in number and intensity over the years, might attempt to mitigate state interference by complying with policies wherever deemed harmless and also by telling officials (including crop assessment field enumerators) what they want to hear. As farmers were aware of a strong government interest in raising food crop yields and production levels from 2008 onwards (top-down communication is well organised, occurs regularly and is effective in reaching people), they might have 'played along' by reporting strong food crop growth. As the targeted results were reported to have been achieved each year, there was no incentive for responsible bureaucrats to further investigate whether the findings were correct.[32]

The second channel concerns the distinct agricultural data collection system of local government agronomists and the performance contract system which drove their actions. It was shown in section 3.6 that imihigo reports strongly overreported achieved crop-specific land use consolidation and realised yields within these sites and that this continued even after official statistics were adjusted downwards in 2014. This type of false reporting is known to occur due to "perverse incentives […] connecting data to financial incentives without checks and balances" (Sandefur and Glassman 2015:129). In particular, from 2008, district governments were given very ambitious land use consolidation as well as yield growth targets. In order to keep their jobs, local government employees have to perform well (Versailles 2012), which is measured solely in imihigo achievement reports. As a result, public officials often only care about quantified imihigo targets bar any reasonable deliberations (Kathiresan 2012) and are incentivised to tweak the numbers wherever necessary and possible. While there is a thorough annual district imihigo auditing process, auditors have very limited time to check the veracity of reported accomplishments. Both the amount of consolidated land and harvested yields on these sites are hence impossible to verify or falsify. Therefore, district governments had a particularly high incentive to overreport their achievements in this area (and in particular to report full achievement of targets). The Rwandan government was aware of structural problems in the performance contract system, namely unrealistically high targets, inadequate funding and poorly defined indicators, as early as 2010 (RoR 2010). Over the years, evidence of deliberate performance overreporting has been uncovered in various sectors (Huggins 2014:375; Linek 2020:30; Williams 2017:555) and in 2019, systemic imihigo data fabrication by districts was raised as a critical problem by the Rwandan prime minister (Sabiiti 2019).

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[32] It appears very implausible that farmers themselves believed production and yield levels to skyrocket over several years while they were in fact not. Thus, accidental overestimation by peasants accumulating over several years can be dismissed.

Now, local government agronomists were aware of biannually conducted crop assessment surveys that independently estimated food crop production, area and yield, which would allow to compare results of both systems on district level. The interviewed former senior manager at MINAGRI remarked that district and sector agronomists cannot overreport their achieved results (too strongly), as this would be detected when crop assessment surveys found much smaller production in their area. While it is not clear whether there was a mechanism to actually cross-check results and hold local governments accountable for deviations, the general possibility of such an examination provides an incentive for agronomists to influence crop assessment surveys in their area.

Field enumerators of crop assessment surveys relied on rough eye estimates as well as farmer recall and forecasting estimates regarding yields and production. Peasants were also directly asked for the size of their crop-specific area. Local agronomists who visit peasants regularly can easily tell them how large their area of each crop (supposedly) is and what yield and production they have reached or are about to achieve during each season, relying on their 'expert' status.[33] Then, both the well-known tendency in Rwanda to not question authority and farmers' self-interest in telling the government what it wants to hear (and what the local government wants them to say) would result in peasants strongly overreporting (consolidated) area, yield and production.

Additionally, it is easy for district and sector agronomists (and some of their representatives on lower administrative levels) to be informed in real-time which farmers are visited by field enumerators. This is because of the very high population density and the particularity of rural political and societal structures in Rwanda, described by Prunier as exhibiting an "almost monstrous degree of social control" (Prunier 1997:3). In particular, there are informal government representatives on the local level that are responsible for the administration of ten households, which means that virtually any relevant event occurring in any rural place can always be known instantaneously by someone connected to the government. This would allow agronomists to remind peasants about their estimates of crop-specific area, yield and production before they answer to the questions of field enumerators.

Potential Driver Exacerbating Overreporting

It is obvious and hardly accidental that the start of the structural overestimation in 2008 coincides with the start of the CIP in season 2008A. Furthermore, it is possible that parts of the programme were not carefully planned in agricultural strategies beforehand (which is usually the case for well-organised Rwanda), but arose rather spontaneously from the President himself. A special auditor general report on the CIP illustrates that in 2007, Rwanda was suffering from severe food insecurity, and that as a result, the President demanded from all ministers involved in rural

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[33] Their estimation results might have been partially driven by a semi-conscious bias based on the expectation of rising yields due to the increased application of inputs (Desiere, Staelens, and D'Haese 2016).

development to "launch […] the green revolution in Rwanda" and to "immediately end hunger" (Auditor General 2010:8). There appear to exist a few internal government documents describing specific agricultural plans but only in 2011, i.e. four years after the launch, and only as a result of the auditor general's lament about the lack of any written text, a CIP strategy document was produced by an external consultant and published by MINAGRI (Kathiresan 2011). Even more, the second Strategic Plan for the Transformation of Agriculture in Rwanda (PSTA II) finalised in December 2008 and published in February 2009 hardly mentions the CIP (which started in late 2007) and its main rationales of regional crop specialisation and land use consolidation but sets different priorities and goals instead (MINAGRI 2009c). Therefore, it might well have been the case that the President made an ad-hoc decision about extremely ambitious goals and potentially about some measures to achieve them, and that the Rwandan governance apparatus rushed to both implement the central CIP pillars (land use consolidation and mineral fertiliser distribution) as thoroughly as possible (thus causing much disruption and damage as captured in micro-level studies cited above) and to tweak the result reports where necessary.

Eventual Detection and Correction

In an ideal world, agricultural statistics and performance monitoring would have immediately detected the ineffectiveness of the disruptive measures described above in producing production and yield growth. If it were found that both total and priority crop production levels and yields had not (or hardly) increased since the CIP start in late 2007, various significant aspects of the agricultural strategy might have been adapted and changes would have been implemented. However, as shown above, agricultural statistics as produced by MINAGRI's crop assessments from 2008-2014 as well as performance monitoring from district imihigo contracts created the illusion that priority crop production levels and yields skyrocketed.

Only the introduction of seasonal agricultural surveys by NISR in 2013 revealed massive overestimation. Official statistics were eventually corrected in 2014, meaning that grossly false numbers proliferated for 'only' six years. This correction was a result of the transformation of the agricultural data collection and compilation system arguably propelled by continuous improvement efforts based on the disinterested pursuit of technocratic excellence. Even more, despite all secretiveness and deception deployed in external communication, the inconvenient truth of failing to engineer an Asian-style Green Revolution was internally accepted. The agricultural statistics system evolved from a standard routine system of administrative data collection in combination with a simplistic crop production forecasting survey that was highly vulnerable to manipulation towards having established and incrementally augmented a state-of-the-art seasonal agricultural survey with a sophisticated sampling technique applying a quite reliable estimation method of GPS area measurement and a mixture of produce weighing and very timely questionnaires for yield metering. With a high degree of confidence, Rwandan

agricultural statistics can be deemed reliable and sufficiently accurate since 2013.[34] The FAO adopts all Rwandan numbers without changing them manually since 2014, and overall production, area and yield data as well as crop-specific numbers have all converged and are now identical for most indicators in Rwandan and FAO datasets.

Without having access to internal communication, the exact process of detection and correction cannot be traced. However, a few interesting things can be pointed out. First, the results of NISR's initial SAS 2013 were not included in any other document, neither in official MINAGRI numbers (reported to the FAO) nor in the statistical yearbook (even though it is published by NISR as well). Even more, the SAS 2013 report itself tiptoed around the meaning of its results. In its foreword and executive summary it omits its most important results (i.e. production levels and yields) and concentrates on less relevant summary statistics such as the relative share of different crops across seasons. It also never compares its results with the NAS 2008 or official statistics of 2012. Second, when MINAGRI accepted the SAS 2014 numbers as official, leading to a major break in the time series, this was mentioned nowhere. On the contrary, both MINAGRI annual reports and NISR statistical yearbooks, both of which had published easily comparable time series of the evolution of food crop production and yields in tables and graphs for years, abruptly discontinued them. In its annual report 2014/15, MINAGRI reported low SAS 2015 numbers and compared them to low SAS 2014 numbers, while the statistical yearbooks stopped to contain production numbers at all. Third, Agnes Kalibata, the widely celebrated agriculture minister whose tenure as full minister started in July 2009 after having been state minister since March 2008, was sacked in July 2014 (around the time the meaning of SAS results would have become clear) and the Rwandan government newspaper associated the firing with dismal performance (Munyaneza 2014). Kalibata briefly held a post as university administrator that represented a strong decline in responsibility before then becoming the managing director of the prestigious Alliance for a Green Revolution in Africa (AGRA) in September 2014 (NAS 2019) and a UN Special Envoy in 2021 (UN 2019).

4.3 Emergence and Maintenance of False Agricultural Success Reputation

While the Rwandan government was not able to sustainably raise food crop production levels and yields, it proved capable of creating and maintaining a robust reputation of having done so. The original emergence of the country's agricultural success story was obviously based on the overreported production and yield growth numbers, which were accepted by FAOSTAT, academics and donors. Rwanda's massive increase in mineral fertiliser imports, its well-formulated agricultural transformation strategies, its general technocratic capabilities, and the observable zeal with which agricultural reforms were implemented made its agricultural growth statistics plausible. The real question is how it was possible that the public image of

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[34] The parallel existence of an imihigo system that still had not adjusted massive overreporting in land use consolidation and yields by 2018 as well as continuously rising food crop GDP numbers remain major caveats to this notion.

Rwanda's highly successful agricultural transformation was upheld after it adjusted its official agricultural statistics strongly downwards in 2014 and officially exhibited low production and yield growth from then on.

The first ingredient was certainly its silence on these developments in any document or communication as described above. A second factor that should not be underestimated is the willingness of parts of the international community and donors to believe in Rwanda's success, to which they feel to have substantially contributed with various development cooperation projects. Closely connected to this is the psychological mechanism known in marketing as Halo effect, which describes the "tendency for an impression created in one area to influence opinion in another area" (Lexico 2021). In particular, someone witnessing many truly remarkable developments in post-genocide Rwanda and having seen both physical evidence and statistics of rapidly improving agriculture, might (unconsciously) ignore, dismiss or explain away new evidence of failing agricultural reform.

Unfortunately, even the knowing complicity of international organisations cannot be ruled out, as exemplified by the allegations of some researchers (Anonymous 2019; Desiere 2017) and a Financial Times article (Wilson and Blood 2019) about the World Bank deliberately covering for Rwanda's 2011-2014 poverty number fiddling. In the case of agricultural statistics, there are some recent reports that suspiciously bypass key performance indicators of yield growth or remain oddly generic in their formulations.[35] The 2019 flagship report "Future Drivers of Growth in Rwanda" by the World Bank and the Government of Rwanda states that "productivity in agriculture has increased strongly" (World Bank Group and Government of Rwanda 2019:221). A recent FAO report reviewing Rwanda's food and agriculture policy succeeds in largely avoiding any substantial figures on production level and yield growth. One graph shows the 2013-14 yield drop in rice without discussing it and the CIP is described in a way as if it was just starting and no results were available yet (Tuyishime et al. 2020). A comprehensive IMF report states that "interventions [in the agricultural sector] have focused on increasing yields […]. Productivity has improved through expanded irrigation and fertilizer use, the use of improved seeds, and consolidation of land used for larger-scale agriculture" (Redifer et al. 2020). As evidence for both food crop stagnation and temporary overreporting is easily accessible, it is hard to not conclude that reports of international organisations continued to tell the Rwandan agrarian success story against their better knowledge.

A final and arguably central determinant of Rwanda's continued agricultural success reputation are the brand-building capabilities of its government.[36] On the one hand, regular contributions on Internet platforms of international organisations (Thomas 2014 (IMF); UNCTAD 2014; World Bank 2015) as well as occasional articles in

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[35] This is on top of FAOSTAT not issuing a publicly available note regarding its significant retrospective data correction, as discussed in section 3.3.

[36] See Pottier (2002) and Reyntjens (2013, ch.5) for a general illustration of the post-genocide Rwandan ruling party's genesis and its ability to effectively communicate on the international level.

widely read international media promote Rwanda's agricultural success story. Most prominently, a 2015 Guardian article co-authored by Agnes Kalibata details how Rwanda excelled in eradicating food insecurity and strongly decreased poverty by raising agricultural productivity and deploying Green Revolution measures (Kalibata and Roy 2015). This article was published at a time when stagnating yields and massive overreporting were already well known to the Rwandan government. A more recent article written by Kalibata in the Financial Times (Kalibata 2017) and an interview with her in Time magazine (Baker 2021) mention Rwanda's agricultural success as a well-established fact in passing.

On the other hand, Rwanda's brand-building occurs via the government's skilful navigation of international efforts to raise agricultural productivity on the African continent. This can be illustrated by looking at Rwanda's top performance in the Comprehensive Africa Agriculture Development Programme (CAADP), a major African Union initiative to boost agricultural transformation in its member states. Key goals include increased agricultural investment of 10% of governments' annual budgets and 6% of agricultural growth per year. Rwanda was the first country to sign the compact in 2007 and designed its agricultural transformation strategy in close alignment with CAADP (Golooba-Mutebi 2014). In both the first and second review exercise in 2017 and 2019, Rwanda ranked first out of 47 and 49 participating African countries, respectively. However, the detailed results for 2017[37] reveal that Rwanda's remarkable scoring was strongly based on procedural and input indicators and sub-indicators, and less so on output or development indicators. For instance, Rwanda ranks first and third respectively on the two procedural indicators "Re-committing to CAADP Process" and "Mutual Accountability for Actions and Results". While these milestones are certainly important and Rwanda did also perform quite well in more substantial indicators such as "Enhancing Resilience to Climate Variability" (ranked first), in the key outcome "Doubling Agricultural Productivity", which was only a sub-indicator, Rwanda ranked 31st out of 47 (African Union 2018).[38] In sum, Rwanda topped the list because of its ability and willingness to satisfy procedural metrics.

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[37] A comprehensive internet search could not find detailed 2019 results.

[38] The Africa Agricultural Transformation Scorecard used by CAADP uses seven equally weighted indicators, which consist each of two to five sub-indicators (21 in total), to come up with a final score. For each sub-indicator, there is a benchmark score to be reached until a given year and every country is shown to be on track or not for each target. Unfortunately, the performance measurement system suffers from a severe arithmetic weakness. For example, indicator 3 "Ending Hunger by 2025" has five sub-indicators which go from 0-10 and are all weighted equally. However, the respective benchmarks, i.e. expected achievable targets, vary between 1 and 10. Actually, three of the five sub-indicators have targets of 1.00 ("Doubling agricultural productivity", "Reduction of post-harvest loss" and "Improving food security and nutrition"), while one has 5.53 ("Access to agriculture inputs and technologies") and one has 10.00 ("Strengthening social protection"). This means that a country that manages to double its agricultural productivity and reaches 90% of its social protection targets is given the same points for these two sub-targets (1+9) as a country that achieves no productivity growth and achieves 100% of its social protection target (0+10). As a result, the scorecard contains major implicit and highly questionable assumptions about which measures are most important to bring about an agricultural transformation as well as which development indicators best capture success.

In a nutshell, the Rwandan government was able to maintain its image as a successful agricultural transformer by banking on the international community's need to believe in major African success stories (or even 'growth miracles') and possibly even the intentional selectiveness of international development organisations regarding evidence consideration, and by communicating effectively and using its technocratic capabilities to excel at globally renowned frameworks. This has so far sufficed to be universally recognised as a continental Green Revolution paragon with skyrocketing yields, while the evidence demonstrating the opposite has been mounting since 2013.

5. Conclusion

This paper provided new evidence in on-going academic debates on the political economy of post-genocide Rwanda. It established that food crop production levels and yields (almost) stagnated in the country from 2005-2019 despite the rigorous implementation of the government's ambitious agricultural reform programme that included massive land use consolidation, application of huge amounts of mineral fertiliser as well as the proliferation of other yield-driving techniques. The most plausible explanation for this conundrum was identified as the massive upheaval caused by the abrupt disruption of agricultural practices resulting from a forceful implementation of over-rigid agrarian reform measures. Additionally, substantive evidence for massive overestimation of production volumes and yields of key food crops from 2008-2013 by Rwandan authorities was provided. The origin and evolution of the overreporting, it was argued, was heavily influenced by the country's performance contract system that compelled local agronomists to report target achievement in land use consolidation and yield growth independent of actual success. The ruling elite's unrealistically high expectations coupled with its uncompromising enforcement might have encouraged agronomists to command peasants to report high yield growth results and led farmers to report the numbers that were expected of them on their own account. Finally, it was postulated that Rwanda's reputation as a successful agricultural transformer remained solid due to a combination of the country's excellent brand-building capabilities and a desire of international organisations to believe in the success narrative.

However, it would be incorrect to paint Rwanda's agricultural reform as a general (or total) failure. Based on the low-growth path composed of NAS 2008 and SAS 2013-2019 numbers, food crop production volumes and yields *were* increasing moderately after all. And even the most scathing critiques agree that –given the country's general situation and demographic trends– profound structural change was (and still is) necessary to develop the country in general and its agrarian sector in particular (Ansoms 2020). The Rwandan government designed and implemented its

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Considering the seven best performing countries concerning yield growth in 2017 (i.e. those that reached the particular benchmark target), their overall ranking is quite low (between 9th and 41st place). While some of them might have indeed not made good progress in other important areas, their impressive results in yield growth counted for less than 1% of their total score (African Union 2018).

agricultural transformation programme based on its modernisation ideology and by applying performance contracts as a military-style enforcement instrument that does not allow failure or discretion. While this approach was tremendously successful in several other domains, most importantly re-asserting political and social control in the country and impressive state-building (Jones 2014), it turned out to be inappropriate to handle the complex intricacies of transforming traditional intensive hill-side subsistence agriculture. Nevertheless, the particular practices of the government led to the development of a state-of-the-art agricultural statistics system that endogenously discovered massive food crop overreporting (which, however, was an endogenous product of the Rwandan governance system itself). The authorities built strategic food reserves, heavily invested in and constructed infrastructure for post-harvest storage, transport and logistics, built agro-processing factories (as a part of Rwanda's industrial development based on a rare competitive advantage), and devised and implemented value-based export strategies regarding the traditional cash crops coffee and tea as well as the new agrarian sub-sectors of horti-, flori- and sericulture. Not all of these endeavours have (yet) worked out, but it would be unjust to deny the genuine and enormous efforts of an institutionalised state system to make them work.[39] Furthermore, administrative and decentralisation reforms, the universal land titling programme and other measures did make the Rwandan countryside more 'legible', which –despite all justified critique on the overzealous high-modernist social engineering of the country's ruling elite– *is* a necessary ingredient of holistic and fundamental socio-economic development.

Most importantly, there are some signs that the government has understood and internalised that developing the agricultural sector requires more nuance, both in allowing local agronomists and farmers more discretion in their production and technology decisions, and including their knowledge to build better general strategies (Ansoms 2019). This was at least partially driven by increasing resistance and complaining of peasants, presumably exacerbated by food shortages coinciding with the 2017 Presidential election (Ansoms 2020). Both growing more food security crops (sorghum, sweet potatoes) and intercropping practices are allowed again under official policies (ibid.). Moreover, in recent years, the Rwandan parliament has critically assessed the Ministry for Agriculture, and demanded written or in-person answers to its concerns (Kwibuka 2019; Mbonyinshuti 2018).

This paper did not argue that Rwanda's government and its governance system were ineffective or dysfunctional *per se*. The relevant benchmark cannot be the most successful transforming Asian countries but Rwanda's own immediate post-genocide situation. When comparing its prospects at that point in time with its current status

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[39] While personal priorities of the President remain the strongest driver for government action in Rwanda, even without direct Presidential scrutiny, the institutionalised governance system of annual budget planning and supervision, performance contract design, monitoring and evaluation, and a culture of hard work in ministries and local governments (Chemouni 2019) ensures that continuous work to improve the agricultural sector does take place. This might not be particularly efficient and sometimes not very effective, but continuous attempts are being made.

quo, many accomplishments (not its political and human rights situation) do indeed come close to a miracle. However, the presented evidence on serious flaws in the Rwandan performance contract system regarding agricultural transformation are in line with case studies on Rwanda's industrial development where the government did not learn from failure and fell short of adapting its policies accordingly as well (Behuria 2015, 2018). Therefore, it appears that regarding the complex processes of economic transformation (including agricultural modernisation and industrial development), the current imihigo system does not constitute a political economy where organisations, companies and individuals are encouraged or compelled to learn through failure and adaptation, but rather to pretend to have succeeded.

Whether the important but so far cautious developments concerning less rigid policy implementation will transform into a necessary structural reform of Rwanda's governance and performance contract system that allows more deliberation and entails a more effective policy correction mechanism, including the possibility to discuss and criticise processes and goals and to allow occasional failure in order to learn, is uncertain. However, nothing less might be needed if Rwanda wants to achieve its ambitious target of becoming a middle income country within a generation.

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Appendix

Appendix 1: Overview of Most Post-genocide Surveys Collecting Agricultural Data in Rwanda

Figure A1: Visualisation of most post-genocide surveys collecting agricultural data in Rwanda
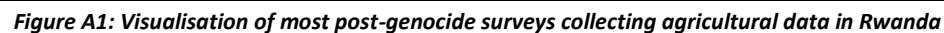
Appendix 2: List of Data Sources

Bugesera District Imihigo 2011-2012

Bugesera District Imihigo 2012-2013

FAOSTAT Dataset Rwandan Agricultural Production, Area & Yield Data 2000-2018 (downloaded 10 February 2015)

FAOSTAT Dataset Rwandan Agricultural Production, Area & Yield Data 2000-2018 (downloaded 13 December 2019)

FAOSTAT Dataset Rwandan Fertiliser Data 2000-2018

Gakenke District Imihigo 2011-2012

Gakenke District Imihigo 2012-2013

Gakenke District Imihigo 2013-2014

Huye District Imihigo 2011-2012

Huye District Imihigo 2012-2013

Huye District Imihigo 2013-2014

IFDC Dataset Rwandan Fertiliser Data 2000-2018

Kicukiro District Imihigo 2011-2012

Kicukiro District Imihigo 2012-2013

Kicukiro District Imihigo 2013-2014

MINAGRI Annual Report 2007

MINAGRI Annual Report 2008

MINAGRI Annual Report 2009/10

MINAGRI Annual Report 2010/11

MINAGRI Annual Report 2011/12

MINAGRI Annual Report 2012/13

MINAGRI Annual Report 2013/14

MINAGRI Annual Report 2014/15

MINAGRI Annual Report 2015/16

MINAGRI Annual Report 2016/17

MINAGRI Annual Report 2017/18

MINAGRI Annual Report 2018/19

MINAGRI Backward Looking Joint Sector Review Report 2008-2009

MINAGRI Backward Looking Joint Sector Review Report 2014-2015

MINAGRI Backward Looking Joint Sector Review Report 2015-2016

MINAGRI Backward Looking Joint Sector Review Report 2017-2018

MINAGRI Backward Looking Joint Sector Review Report 2018-2019

MINAGRI Crop Assessment 2009B

MINAGRI Crop Assessment 2010A

MINAGRI Crop Assessment 2010B

MINAGRI Crop Assessment 2012A

MINAGRI Imihigo 2017-2018

MINAGRI PSTA I

MINAGRI PSTA II

MINAGRI PSTA III

MINAGRI PSTA IV

MINECOFIN EICV I

Muhanga District Imihigo 2011-2012

Muhanga District Imihigo 2013-2014

NISR Agricultural Household Survey 2017

NISR EICV II

NISR EICV III

NISR EICV IV

NISR EICV V

NISR National Agricultural Survey 2008

NISR Seasonal Agricultural Survey 2013 version 1

NISR Seasonal Agricultural Survey 2013 version 2

NISR Seasonal Agricultural Survey 2014

NISR Seasonal Agricultural Survey 2015

NISR Seasonal Agricultural Survey 2016

NISR Seasonal Agricultural Survey 2017

NISR Seasonal Agricultural Survey 2018

NISR Seasonal Agricultural Survey 2019

NISR Statistical Yearbook 2008

NISR Statistical Yearbook 2009

NISR Statistical Yearbook 2010

NISR Statistical Yearbook 2011

NISR Statistical Yearbook 2012

NISR Statistical Yearbook 2013

Nyabihu District Imihigo 2012-2013

Nyabihu District Imihigo 2013-2014

Nyamagabe District Imihigo 2011-2012

Nyamagabe District Imihigo 2013-2014

REMA Agricultural Report (n.d.)

Republic of Rwanda Vision 2020

Republic of Rwanda Agriculture Joint Imihigo 2015-2016

Republic of Rwanda Agriculture Joint Imihigo 2016-2017

Republic of Rwanda Agriculture Joint Imihigo 2017-2018

Republic of Rwanda Agriculture Joint Imihigo 2018-2019

Republic of Rwanda Districts Imihigo Evaluation Report 2009-2010

Republic of Rwanda Districts Imihigo Evaluation Report 2010-2011

Republic of Rwanda Districts Imihigo Evaluation Report 2011-2012

Republic of Rwanda Districts Imihigo Evaluation Report 2012-2013

Republic of Rwanda Districts Imihigo Evaluation Report 2014-2015

Republic of Rwanda Districts Imihigo Evaluation Report 2015-2016

Republic of Rwanda Districts Imihigo Evaluation Report 2016-2017

Republic of Rwanda Districts Imihigo Evaluation Report 2017-2018

Ruhango District Imihigo 2011-2012

Ruhango District Imihigo 2012-2013

Ruhango District Imihigo 2013-2014

Rusizi District Imihigo 2011-2012

Rusizi District Imihigo 2012-2013

Appendix 3: Overreporting of Consolidated Area and Yield for Individual Crops in District Performance Contracts in 2011-2013

For the fiscal years 2011/12 and 2012/13, nine district performance contracts could be found on the respective district government websites. Table A3.a shows the reported baselines for the consolidated area (in ha) for the six priority crops. Baseline numbers do not necessarily represent the status quo of previous years but they do come reasonably close to justify equating them with actual results of the previous year in this exercise. Following this logic, it can be seen that all nine districts had already achieved some consolidation in maize area, eight had accomplished pooling for beans and seven for cassava. Land use consolidation for rice, wheat and Irish potatoes were only included in the performance contracts of a few of the nine districts. The second last column in table A3.a describes each district's cultivated area as a share of Rwanda's total cultivated area and shows that the nine districts account for 27.3% of the total. These calculations were made based on numbers from the Seasonal Agricultural Survey 2017, as earlier numbers do not exist. However, it can be reasonably assumed that there was no significant change of the share of cultivated land between these nine and the other twenty-one districts.

Table A3.b depicts the baseline yields (in t/ha) for these nine districts and six crops. It can be seen that a yield target was not set for all crops which had an area target. However, there are enough entries to calculate a large portion of production volumes (in t) in these consolidated areas (see table A3.c). The production volume for each of the crops is added up and then extrapolated to the whole country by scaling up the 27.3% share of cultivated land to 100%. If comparing these numbers to the reported total crop production in 2012 in the MINAGRI report 2012/13, coincidentally the numbers for wheat and beans match almost exactly. Also cassava numbers are close (AR numbers being 7% higher than extrapolated imihigo numbers). However, for maize, rice and Irish potatoes, the extrapolated production according to performance contracts were significantly *higher* than the annual report numbers. As it was shown that the latter numbers were strongly inflated and since five of six imihigo crop numbers are equal or even larger, it can be concluded that the performance contract data fits much better with the high-growth path than with the low-growth path.

There are two main factors why these calculated and extrapolated imihigo production volumes can be quite off the actually reported numbers by all thirty districts. First, districts can differ a lot in their climate, soil and agro-ecological zone, therefore there are regional foci, which can mean that the quasi-random sample of the nine districts over- or underrepresents some of the crops significantly. Still, the nine districts represent all five provinces of Rwanda. This misrepresentation could bias extrapolated numbers in both directions. Second, these numbers only account for the production in consolidated areas. A large part of total agricultural land is still not consolidated and it is not possible to infer the production in these areas from the existing numbers, as the yields can be quite different (supposedly significantly lower, as fertiliser subsidies and improved seeds handouts are only intended for

consolidated areas). However, the total production of all non-consolidated areas for the six crops are missing completely. Therefore, the extrapolation is an estimate of the lower bound of total production, while it is already 21% larger for the sum of the six crops than the annual report numbers. Also, some yield numbers are missing, thereby leading to missing entries in the production table. This leads to an underrepresentation of crop production as well.

In conclusion, this analysis shows that reported numbers of consolidated area and yield on these sites for 2011/12 and 2012/13 are in line with or even higher than annual report data. Thus, imihigo statistics also significantly overreport agricultural output indicators.

a) Baselines Consolidated Area (ha)									
District	Maize	Rice	Wheat	Beans	I. Potato	Cassava	Total	Cult. Area %	Rep. Year
Nyabihu	12,953		4,628	10,973	16,623		45,177	0.5%	2011/2012
Nyamagabe	8,018		8,196	12,968	16,174	4,035	49,391	2.1%	2012/2013
Huye	2,564	2,511				7,336	12,411	2.8%	2011/2012
Bugesera	12,000			12,199		20,541	44,740	3.6%	2011/2012
Muhanga	3,790	496		21,286	320	10,745	36,637	3.6%	2012/2013
Gakenke	15,612		762	20,527	5,004	1,691	43,596	2.6%	2012/2013
Ruhango	3,952	1,400		16,899		14,296	36,547	3.1%	2012/2013
Rusizi	12,257	2,560		23,475		7,149	45,441	4.0%	2012/2013
Kicukiro	1,600			3,000			4,600	5.0%	2012/2013
Total	72,746	6,967	13,586	121,327	38,121	65,793	318,540	27.3%	

b) Baselines Yield (t/ha)							
District	Maize	Rice	Wheat	Beans	I. Potato	Cassava	Rep. Year
Nyabihu	4.1		2.3	2.4	26.1		2011/2012
Nyamagabe	3.4		1.3		22.5	30.0	2012/2013
Huye	3.4	5.8			29.0		2011/2012
Bugesera		7.5					2012/2013
Muhanga	3.7	5.9			19.0		2012/2013
Gakenke	4.6		2.8	2.2	17.9	26.0	2012/2013
Ruhango	3.6	5.0				25.1	2012/2013
Rusizi	3.0	6.5		1.8		18.0	2012/2013
Kicukiro	3.5			0.7			2012/2013

c) Calculated Production (t)							
District	Maize	Rice	Wheat	Beans	I. Potato	Cassava	Total
Nyabihu	53,107		10,644	26,335	433,860		523,947
Nyamagabe	27,261		10,655		363,915	121,050	522,881
Huye	8,718	14,564					23,281
Bugesera							0
Muhanga	14,023	2,926			6,080		23,029
Gakenke	71,659		2,134	45,159	89,572	43,966	252,490
Ruhango	14,227	7,000				358,830	380,057
Rusizi	36,771	16,640		42,255		128,682	224,348
Kicukiro	5,600			2,100			7,700
Total (27%)	231,366	41,130	23,433	115,850	893,427	652,528	1,957,733
Extrapol. (100%)	856,913	152,334	86,788	429,073	3,308,989	2,416,769	7,250,865
AR 12/13: 2012	569,590	83,260	86,780	431,020	2,239,164	2,595,798	6,005,612
Difference	50%	83%	0%	0%	48%	-7%	21%

Table A3: Baselines of consolidated area and yields and calculated production in nine Rwandan districts 2011-2013

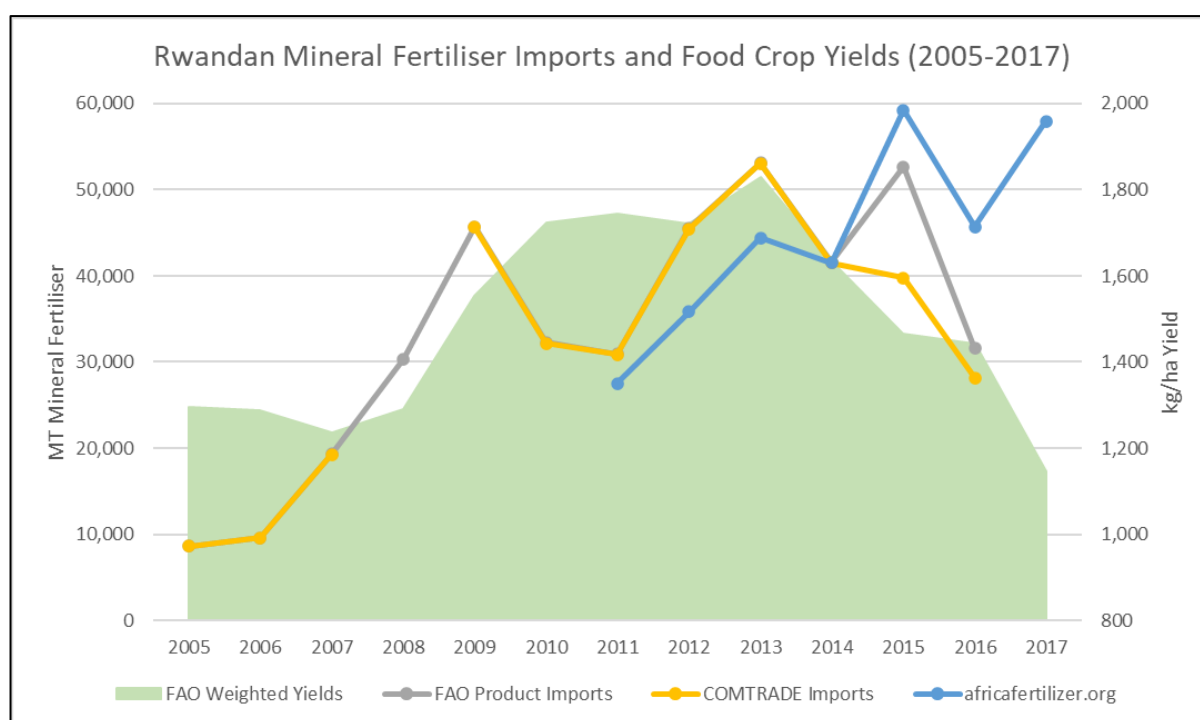## Appendix 4: Rwandan Mineral Fertiliser Data

Figure A4: Rwandan mineral fertiliser import and food crop yields (2005-2017)