

Agricultural land use and economic efficiency around the Tonle Sap Lake and Cambodian Mekong River

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Paper submitted 21 March 2021, revised manuscript accepted 27 April 2021.

មូលនិយមសង្ខេប

ប្រទេសកម្ពុជាបានផ្លាស់ប្តូរជាញឹកញាប់នូវរបបនយោបាយ និងសេដ្ឋកិច្ចក្នុងរយៈពេលប៉ុន្មានទសវត្សរ៍ចុងក្រោយនេះ។ ទន្ទឹមនឹងនេះ ការប្រើប្រាស់ដីកសិកម្មក្នុងប្រទេសក៏មានការប្រែប្រួលដែរ។ ការសិក្សានេះធ្វើការវាយតម្លៃលើនិន្នាការនៃការប្រើប្រាស់, ប្រសិទ្ធភាពសេដ្ឋកិច្ច និងការអនុវត្តន៍ដីកសិកម្មពីអតីតកាល (១៩៨០-១៩៨៩), បច្ចុប្បន្ន (២០១០-២០១៩) និងពេលអនាគត នៅតំបន់ជុំវិញបឹងទន្លេសាប, ទន្លេមេគង្គលើ និងទន្លេមេគង្គក្រោមកម្ពុជា។ ការសិក្សានេះធ្វើឡើងក្នុងឆ្នាំ២០១៩ តាមរយៈការសម្ភាសន៍ជាមួយកសិករគោលដៅចំនួន ៧៦គ្រួសារ។ លទ្ធផលបង្ហាញថា កសិករគោលដៅភាគច្រើនអនុវត្តកសិកម្មដំណាំស្រូវ (៧១% នៃអ្នកឆ្លើយតប) និងកសិកម្មដំណាំផ្សេងៗមិនមែនស្រូវ (២៩%) ដែលក្នុងនោះមានដំណាំកៅស៊ូ ១១% និងបន្លែ ៩%។ ទំហំដីកសិកម្មជាមធ្យមមានភាពខុសគ្នារវាងតំបន់សិក្សាទាំង៣។ ផ្ទៃដីកសិកម្មដំណាំស្រូវដែលធំជាងគេគឺនៅតំបន់ជុំវិញបឹងទន្លេសាប។ គ្រួសារនីមួយៗប្រើប្រាស់ដីជាមធ្យម ១.៩ហិកតា សម្រាប់កសិកម្មដំណាំស្រូវ ដែលផ្តល់ប្រាក់ចំណូលប្រចាំឆ្នាំជាមធ្យម ៩២៣ដុល្លារ (៤៨៦ដុល្លារ/ហិកតា) និង ១.៤ហិកតា សម្រាប់ដំណាំមិនមែនស្រូវ ដែលផ្តល់ប្រាក់ចំណូលប្រចាំឆ្នាំជាមធ្យម ៩០២ដុល្លារ (៦៤៤ដុល្លារ/ហិកតា)។ ទំហំដីកសិកម្មមានទំនាក់ទំនងជាវិជ្ជមានជាមួយនឹងប្រាក់ចំណូល ហើយកត្តាប្រឈមសំខាន់ៗក្នុងការធ្វើកសិកម្មមាន គ្រោះរាំងស្ងួត និងសត្វល្អិតចង្រៃ។ ទំហំដីកសិកម្មបានកើនឡើងពី២៨% ក្នុងទសវត្សរ៍ឆ្នាំ១៩៨០ ដល់៣១% ក្នុងទសវត្សរ៍ឆ្នាំ២០១០ ខណៈដែលការអនុវត្តន៍កសិកម្មគ្រួសារបានកើនឡើងពី៧២% ទៅ៨៦%។ ការអនុវត្តន៍កសិកម្មគ្រួសារនេះ ត្រូវបានព្យាករណ៍ថានឹងថយចុះមកត្រឹម៤២% នាពេលអនាគត ចំណែកការអនុវត្តន៍កសិកម្មខ្នាតមធ្យម (ការជួលកម្លាំងពលកម្ម និងគ្រឿងយន្តកសិកម្ម) អាចកើនឡើងដល់៣២% នៃកសិករគោលដៅ។ ការសិក្សារបស់យើងបង្ហាញទៀតថា កសិករគោលដៅ២០% មានប្រាក់ចំណូលច្រើនជាងផលិតផលក្នុងស្រុកសរុបសម្រាប់មនុស្សម្នាក់ (GDP) ដែលបញ្ជាក់ពីប្រសិទ្ធភាពខ្ពស់នៃសេដ្ឋកិច្ចដីកសិកម្មសម្រាប់កសិករទាំងនេះ។ តែទោះជាយ៉ាងនេះក្តី ប្រាក់ចំណូលនាពេលបច្ចុប្បន្ន និងអនាគត របស់កសិករគោលដៅដទៃទៀត ត្រូវបានព្យាករណ៍ថានឹងនៅមានកម្រិតទាបជាង GDP។ លទ្ធផលរបស់យើងក៏បានបញ្ជាក់ថា ការអភិវឌ្ឍន៍ប្រព័ន្ធធារាសាស្ត្រ, បច្ចេកទេសដាំដុះ និងទីផ្សារកសិផលទូលំទូលាយ គឺជាកត្តាដែលត្រូវដោះស្រាយ ដើម្បីលើកកម្ពស់វិស័យកសិកម្មនៅកម្ពុជា។

Abstract

Cambodia has experienced political and economic changes in recent decades and the same is true of agricultural land use in the country. We assessed past (1980–1989), present (2010–2019) and potential future trends in agricultural land-use, economic efficiency and management practices around the Tonle Sap Lake (TSL) and upper and lower sections of the Cambodian Mekong river basin. Interviews were undertaken to this end with 76 households in 2019. Our results

CITATION: Seth K., Touch V. & Sor R. (2021) Agricultural land use and economic efficiency around the Tonle Sap Lake and Cambodian Mekong River. *Cambodian Journal of Natural History*, 2021, 53–60.

indicate that two broad categories of agriculture are practiced, rice-farming (71% of respondents) and non-rice farming (29%), with the latter mainly comprising rubber plantations (11%) and vegetable cropping (9%). The average size of farms differed between study areas, with larger areas devoted to rice-farming around the TSL. On average, households used 1.9 ha for rice-farming and 1.4 ha for non-rice farming, which provided mean annual incomes of US\$ 923 (486 USD/ha) and US\$ 902 (644 USD/ha), respectively. Farm size was positively associated with income. Drought and pests were reported as the greatest farming challenges. Farm areas increased from 28% in the 1980s to 31% in the 2010s, whereas family-scale farming practices increased from 72% to 86%. The latter were projected to decrease to 42% in the future, whereas medium-scale practices (use of hired labour and agricultural machinery) were projected to increase to 32%. Our study indicates that only 20% of respondents have incomes greater than the country's current per capita GDP, suggesting greater economic efficiency in these cases. However, the present and potential future incomes of the remainder were lower than this. Our results suggest that development of irrigation systems and cropping techniques and diversification of markets are required to improve the agricultural sector in Cambodia.

Keywords Agricultural economics, cropping techniques, farming business, productivity and management.

Introduction

Agriculture is one of the most important economic sectors in the Lower Mekong Basin and Cambodia (MRC, 2016). During the 1990s, 2000s and 2010s, the average proportion of Cambodia occupied by agricultural land was approximately 25.8%, 29.3% and 30.9%, respectively (World Bank, 2021). This is cultivated for various crops, with some areas under temporary rice cultivation and other areas cropped for coffee, rubber and fruit trees (ADB, 2021).

Agricultural land use in Cambodia mainly comprises irrigated rice, rubber plantations and corn and cassava cultivation (Lonn *et al.*, 2016) and the nature of ownership varies between different types of farms. For example, most irrigated rice farms are managed by local households, whereas rubber plantations, which typically occupy larger areas, are mostly managed by agri-businesses. This results in different yields and thus different contributions to the national economy.

The overall contribution of agricultural sector to the Cambodian economy has gradually decreased in recent years (NIS, 2015). Notwithstanding this, the annual value of the sector grew from an average of 2.1 billion USD in the 2000s to 4.8 billion USD in the 2010s (World Bank, 2020a). Most rice production is undertaken by households surrounding the Tonle Sap River and lower sections of the Mekong basin (NIS, 2013; MAFF, 2016), whereas rubber plantations are prevalent in the country's northeast, in the upper section of the Mekong basin (NIS, 2013). As a consequence, the relative contribution of each crop type to the agricultural sector varies between regions.

This study assesses past (1980–1989), present (2010–2019) and potential future trends in agricultural land-

use, economic efficiency and management practices in three regions of Cambodia: the Tonle Sap Lake and river system, and the lower and upper sections of the Cambodian Mekong river basin. Our specific aims were to 1) investigate the status of agricultural land use and evaluate the influence of farm size on economic output, 2) determine the extent to which agricultural land use practices contribute to improving farmer livelihoods, 3) identify major challenges for agriculture, and 4) evaluate land use practices to identify opportunities to improve their effectiveness and economic value to local farmers.

Methods

Study areas

Our study included parts of 13 provinces located around the Tonle Sap Lake (TSL) and its river systems (Kampong Chhnang, Pursat, Battambang, Banteay Meanchey, Siem Reap and Kampong Thom), the upper section of the Cambodian Mekong river basin (CUM) (Kampong Cham, Tbong Khmum, Kratie and Stung Treng) and the lower section of the Cambodian Mekong river basin (CLM) (Prey Veng, Kandal and Takeo) (Fig. 1, Table 1).

Data collection

We developed a semi-structured questionnaire which was tested and revised prior to the study. Data collection was undertaken from 23 August to 10 September 2019. The number of households targeted in each study region varied according to the size of the region, with a sampling target of 30–40 households adopted for the TSL region and 20–30 households apiece in the CLM and the CUM regions. In each region, individual households were selected for interviews using a combination of

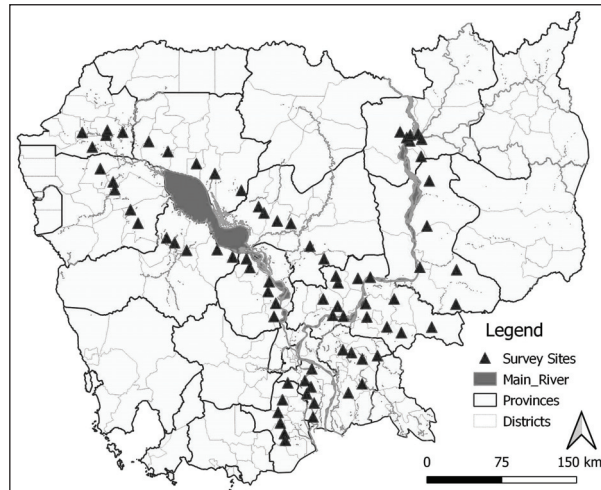


Fig. 1 Study sites in the upper and lower sections of the Mekong basin and around the Tonle Sap Lake, Cambodia.

stratified (by distance) and random sampling to ensure diverse representation. All households interviewed were selected based on their active involvement in agricultural activities, irrespective of their gender.

Four major categories of agricultural activities were recognised during data collection: 1) rice-farming, 2) non-rice farming, 3) rice-farming and non-rice crop types, and 4) other—no species response. Interview data were also arranged in three subsections: 1) agricultural land use and economic values, 2) agricultural challenges, and 3) past, present, and future management practices. Farmer responses regarding the contribution of agriculture to their incomes were categorized as low, medium or high and were solely based on their reported perceptions (as opposed to adopting pre-defined ranges of income for each category). Responses regarding the scale of farming practices were arranged in three categories: 1) family-scale—comprising farms that solely employ the labour of family members who consume most of the produce, 2) medium-scale—farms that employ hired labourers and agricultural machinery and whose yield is mostly for sale, and 3) Other—holdings whose farmers did not directly own the land.

Data analysis

Descriptive statistics were used to quantify the relative proportions of individual agricultural land uses in the three regions and overall incomes generated by respondents for each land use. One-way ANOVA or Kruskal-Wallis tests were employed as appropriate to the data to compare these between regions. Linear regression was used to assess the influence of farm size on incomes. All

Table 1 Number of respondents in each study region. TSL: Tonle Sap Lake, CLM: lower Cambodian Mekong river basin, CUM: upper Cambodian Mekong river basin.

Region	No. Sites	Male	Female	Ages
TSL	32 (42%)	13	19	22–53
CLM	18 (24%)	7	11	24–56
CUM	26 (34%)	7	19	24–53
Total	76	27 (36%)	49 (64%)	22–56

analysis was performed in R (R Core Team, 2019) and employed a p value of ≤ 0.05 as the threshold for significance.

Results

Agricultural land uses and incomes

The majority of respondents (71.1%) surveyed across the three study regions practiced rice farming (Table 2), although the relative proportion varied between regions, ranging from 54% in CUM to 72% in CLM and 85% in TSL region. The proportion of respondents engaged in non-rice farming in each region was correspondingly low, although 31% farmed rubber plantations in the CUM region and 28% cropped vegetables in the CLM region (Table 2).

On average, each rice farmer cultivated 1.9 ± 1.4 ha and earned 486 ± 248 USD/ha and 923 ± 811 USD/year. Average incomes from rice farming did not differ significantly between regions ($p=0.43$, Fig. 2). The equivalent figures for non-rice farmers were 1.4 ± 2.2 ha, 644 ± 350 USD/ha and $902 \pm 1,414$ USD/year (Table 3) and average incomes for these differed significantly between regions ($p=0.002$, Table 3, Fig. 2). In both cases, farm size was positively associated with income (Fig. 3).

Contribution of agriculture to livelihoods and major challenges

Most rice farmers and non-rice farmers ranked the contribution of agriculture to their incomes as low or medium; only five rice farmers regarded this as high, whereas no non-rice farmers ranked it as such (Table 4). Within these categories, the average income for rice-farmers was 543 USD/year (low), 1,313 USD/year (medium) and 3,098 USD/year (high) respectively, whereas for non-rice farmers it was 1,408 USD/year (low) and 2,810 USD/year (medium). Across all study regions and farm types, the

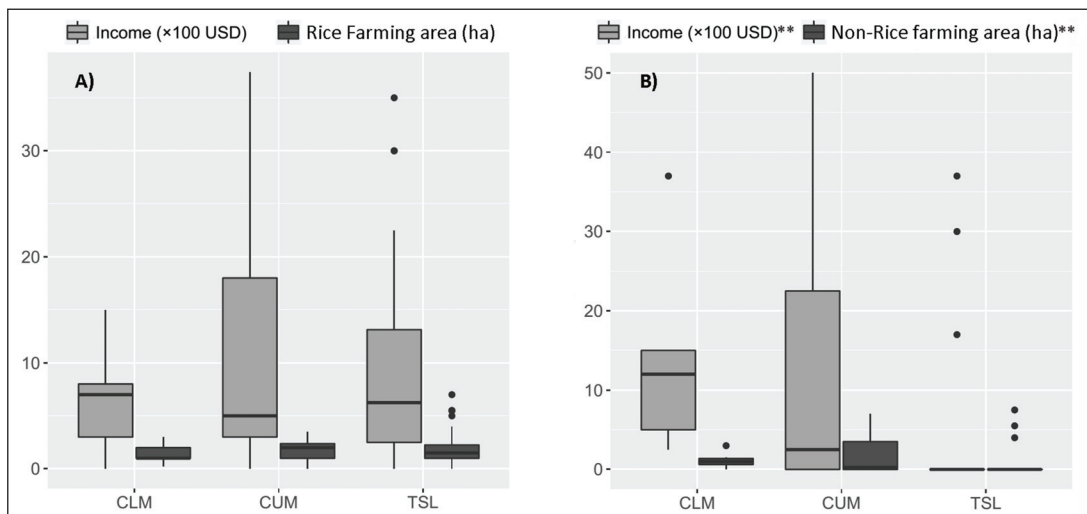
Table 2 Relative proportions of respondents cultivating rice and non-rice crops in each study region. TSL: Tonle Sap Lake, CLM: lower Cambodian Mekong river basin, CUM: upper Cambodian Mekong river basin.

Region	Rice Farming	Non-Rice Farming		Rice Farming & Rubber	Other
		Rubber	Vegetables		
TSL	85% (27)	–	6% (2)	–	9% (3)
CLM	72% (13)	–	28% (5)	–	–
CUM	54% (14)	31% (8)	–	11% (3)	4% (1)
All	71.1% (54)	10.5% (8)	9.2% (7)	3.9% (3)	5.3% (4)

Table 3 Median, mean and standard deviation for farm sizes (ha) and annual incomes (USD) of respondents in each study region. TSL: Tonle Sap Lake, CLM: lower Cambodian Mekong river basin, CUM: upper Cambodian Mekong river basin.

Strategy	Metric	TSL	CLM	CUM	Overall
Rice farms	Land area	1.5 / 2.2 / 1.8	1.0 / 1.5 / 0.8	2.0 / 1.9 / 0.9	1.8 / 1.9 / 1.4
	Annual income	625 / 960 / 818	700 / 727 / 513	500 / 1,012 / 947	663 / 923 / 811
Non-rice farms	Land area**	0.0 / 0.9 / 2.3	1.0 / 1.4 / 1.0	0.5 / 1.9 / 2.4	0.0 / 1.4 / 2.2
	Annual income**	0 / 467 / 1,128	1,200 / 1,430 / 1,366	250 / 1,162 / 1,602	0 / 902 / 1,414

** indicates a significant difference ($p < 0.01$) between regions.

**Fig. 2** Variation in farm size and annual incomes in each region for A) rice farmers and B) non-rice farmers. TSL: Tonle Sap Lake, CLM: lower Cambodian Mekong river basin, CUM: upper Cambodian Mekong river basin. ** indicates a significant difference ($p < 0.01$) between regions.

study respondents earned 549 USD/year with 2.5 ha of land on average.

Drought was reported as the greatest challenge affecting rice farming in the study areas and particularly in the TSL region (Fig. 4). Pest damage was reported by non-rice farmers as the most challenging factor, particularly in the CUM region, followed by drought and pest damage combined.

Past, present and future agricultural practices

Farming areas increased from 28% in the 1980s to 31% in the 2010s. Across all respondents, 72% reported growing rice and other crops in the 1980s, whereas 86% reported the same in the 2010s. During the latter period, the remaining 14% reported practicing medium-scale farming involving the use of hired labour and agricultural machinery (Fig. 5). When asked about their future

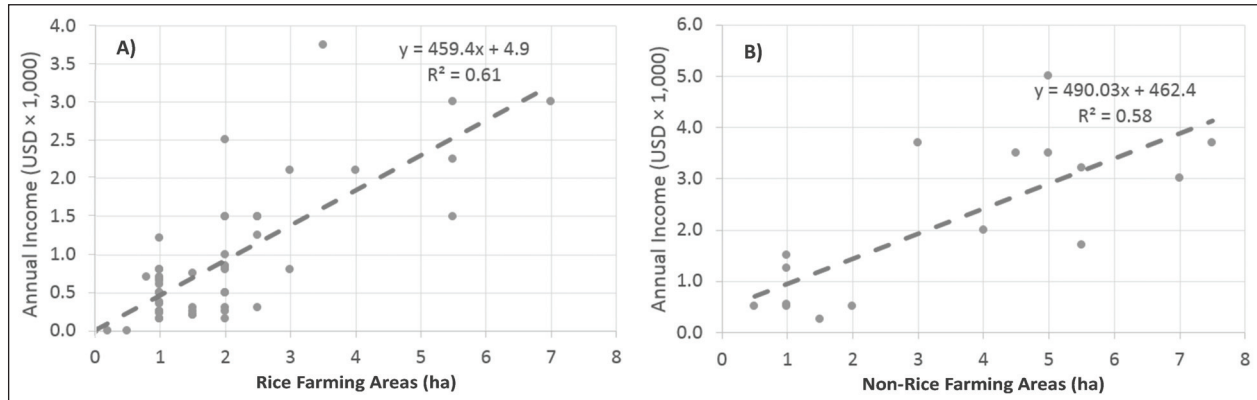


Fig. 3 Relationship between farm size and annual income for A) rice farmer and B) non-rice farmers.

Table 4 Respondent perceptions on the contribution of agriculture to their livelihoods. Figures for farm size and annual income represent mean ± standard deviation values. Data presented excludes respondents who reported ‘no contribution’.

Rank	Rice Farmers			Non-Rice Farmers		
	<i>n</i>	Farm Size (ha)	Income (USD)	<i>n</i>	Farm Size (ha)	Income (USD)
High	5	5.3 ± 1.3	3,098 ± 572	–	–	–
Medium	16	2.3 ± 1.2	1,313 ± 641	10	4.7 ± 1.9	2,810 ± 1,350
Low	27	1.5 ± 0.6	543 ± 348	8	2.1 ± 1.6	1,408 ± 1,311

plans, 42% of respondents expected to continue farming at a family-scale, whereas 32% expected to farm at a medium-scale and the remainder were uncertain (Fig. 5).

When asked how the agricultural sector might be improved in future, 28% of rice farmers suggested this would require better irrigation systems, 15% suggested better market conditions were needed and 57% suggested both. When asked the same question, 82% and 18% of non-rice farmers suggested better market conditions and improved farming techniques were required, respectively.

Discussion

Agricultural land uses and incomes

The majority of respondents in our study were rice farmers, followed by rubber farmers and vegetable farmers. This is unsurprising given these crops are effectively traditional, having been cultivated since the French colonial era (Lonn *et al.*, 2016). It also reflects the specific suitability of areas for different crop species. For instance, because the TSL and CLM regions receive large

volumes of sediment from the Mekong River each year, these are well known for their high fertility and productivity for rice (Kummu *et al.*, 2005). Similar to Goletti & Sin (2016), we also encountered study respondents in the CLM that cultivate vegetables for supply to Phnom Penh. Additionally, because the CUM region is characterised by highlands and mountainous areas which are suitable for rubber cultivation (MAFF, 2016; Mak, 2017), 31% of respondents in this region dedicated their efforts to this crop type.

The land holdings and incomes possessed by rice farmers varied between regions although these differences were not significant. On average, households around the TSL region had more land but lower incomes (ca. 436 USD/ha), whereas those in the CUM region had less land but greater incomes (ca. 533 USD/ha; Table 3). Previous studies have documented higher incomes from rice farming in the northwest area of the TSL region (ca. 513 USD/ha) (Srean *et al.*, 2018). Our results are consistent with previous studies which indicate that the TSL region is highly productive and represents a sizeable portion of the contribution made by the agriculture sector to the national economy (Lonn *et al.*, 2016; MAFF, 2016; MRC, 2016; World Bank, 2020). It is also highly favourable in

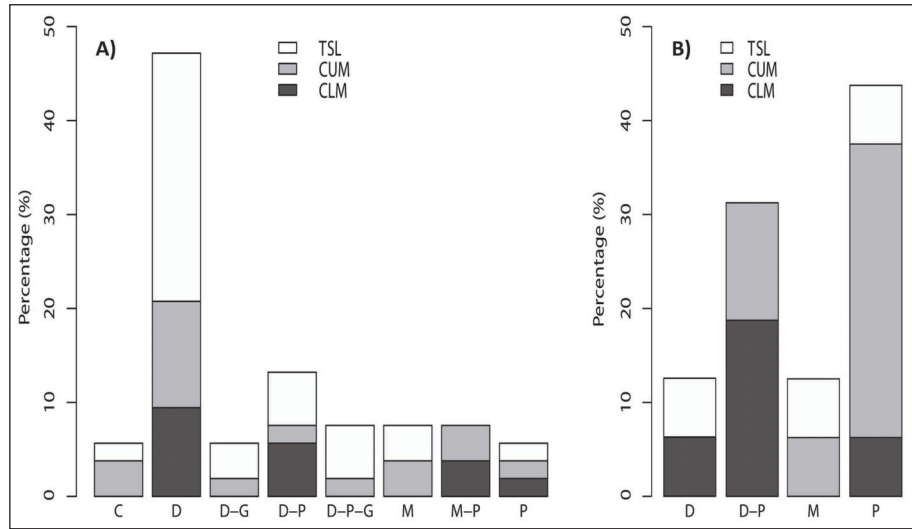


Fig. 4 Relative proportions of respondents who indicated different challenges for A) rice farming and B) non-rice farming in the three study regions (TSL: Tonle Sap Lake, CLM: lower Cambodian Mekong river basin, CUM: upper Cambodian Mekong river basin). Key: C=High costs, D=Drought, G=Weed problems, M=Lack of markets, P=Pest damage.

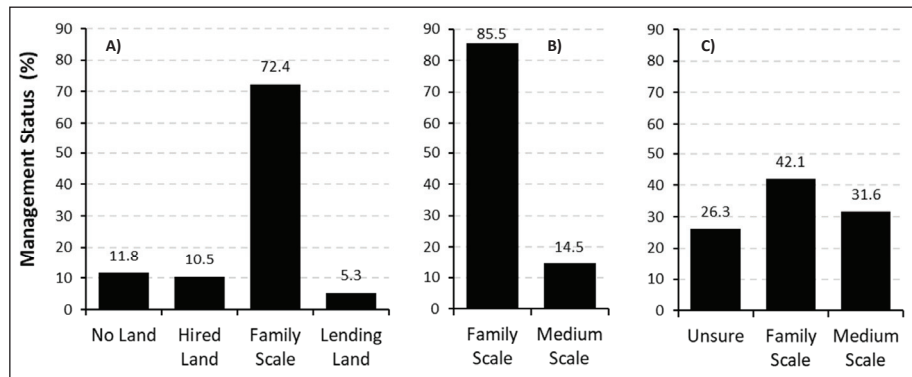


Fig. 5 Status of land ownership and farm management among study respondents in the A) past (1980–1989), B) present (2010–2019) and C) future.

terms of its fisheries (Sor *et al.*, 2017; Ngor *et al.*, 2018a, 2018b). Unlike rice farmers however, the land holdings and incomes possessed by non-rice farmers differed significantly between regions. On average, households in the TSL region had smaller land holdings and lower incomes compared to those in the CLM and CUM regions. This is most likely due to the differing suitability of regions for specific crops, the TSL region being less suited to crops such as rubber or cassava compared to the CUM region (Kummu *et al.*, 2005; Mak, 2017).

As expected, farm size was positively associated with annual income for both rice and non-rice farmers. Partly as a result, households with small holdings coupled with a lack of labour often rent their lands to neighbours who

are better equipped to cultivate these due to their access to hired labour and agricultural machinery. Consistent with this, a gradually increasing trend in small scale rice-farming businesses was observed across the three study regions and particularly the TSL region.

Contribution of agriculture to livelihoods and major challenges

We found that rice farming provides lower incomes (486 USD/ha) compared to non-rice farming practices (644 USD/ha). Crops cultivated in the latter category include rubber, cassava, corn, fruit trees and vegetables (Lonn *et al.*, 2016). Our data suggests that incomes generated from

rice farming are low and thus insufficient for over half of the households we interviewed, whereas relatively small proportions rated their incomes as medium or high (Table 4). Within the non-rice farming category, none of the study respondents rated their agricultural incomes as high, whereas slightly more than half rated these as medium and slightly less than half rated them as low. This is reflected in our finding that on the whole, the study respondents earned 549 USD/year with 2.5 ha of land on average, which is far below the per capita GDP for Cambodia in 2019 (1,643 USD/year) (World Bank, 2020b).

Farmer responses regarding the contribution of agriculture to their incomes (and thus their economic efficiency) were highly variable and entirely dependent on personal perceptions which differed between rice and non-rice farmers. For example, an average income of 543 USD/year was considered low by rice farmers, whereas an average income of 1,408 USD/year was rated as low by non-rice farmers and these groups respectively rated average incomes of 1,313 USD/year and 2,810 USD/year as medium. This suggests that expectations or standards of income among rice farmers are somewhat lower than the non-rice farmers. Nonetheless, our data suggest that only 20% of study respondents (five rice farmers and ten non-rice farmers: Table 4) had incomes greater than the per capita GDP of Cambodia in 2019. At a national level, the contribution of agriculture to economic growth decreased from 30% in the 2000s to 21% in 2018 (NIS, 2015). While this could be partly due to labour shifting from family-scale farming to the garment or other sectors, incomes generated from rice and non-rice farming largely remain below the per capita GDP in Cambodia. Regardless, given the continuing importance of agriculture to the country's economy, development of the sector must be considered an urgent necessity (Lonn *et al.*, 2016).

Drought was the most challenging factor affecting rice production in the three study regions. The TSL region was the most affected area with 28% of respondents identifying this as a major issue, whereas approximately 10% of respondents in both the CUM and CLM regions similarly regarded it as a major issue. This suggests that irrigation systems within these regions and the TSL particularly still need improvement and risk management practices would be beneficial in building community resilience (Lonn *et al.*, 2016), not least because drought events are increasing in the lower Mekong basin (Thilakarathne & Sridhar, 2017; Null *et al.*, 2021). For non-rice farmers, a combination of pest damage and drought were regarded as the greatest challenges. These findings are consistent with previous studies (e.g., United Nations, 2011; Lonn *et al.*, 2016) and actions addressing these issues should

be accorded high priority in future efforts to develop the agriculture sector in Cambodia.

Past, present and future agricultural practices

Our results indicate that agricultural practices have changed over time in the study regions. During the 1980s, 11.8% of respondents had no land for agriculture, whereas 10.5% hired land from others for farming purposes. This is no longer the case, as all respondents owned land and 14.5% have upgraded their farming practices by employing hired labour and agricultural machinery. Additionally, when questioned on their likely farming practices in future, 42% responded they would continue farming at a family scale, whereas 32% reported they would upgrade their practices to include hired labour and agricultural machinery. However, 26% of respondents were not sure what they would do in future, suggesting that these could potentially benefit from further training and other support from the government and agricultural agencies.

Overall, better irrigation and markets for agricultural products were identified by most study respondents as being required to improve livelihoods of rice- and non-rice farmers. Reform of the agricultural sector in Cambodia would seem inevitable and land use planning is recognised as key to sustainable agriculture (De Wrachien, 2001). In addition to improved irrigation systems and markets, development of appropriate cropping techniques is required to adapt to ongoing climate change, as is the adoption of crop species best suited to specific environmental circumstances of different areas (Ironsides, 2010; Lonn *et al.*, 2016).

In conclusion, our study indicates that most farmers currently earn less than the per capita GDP for Cambodia and will likely continue to depend on agriculture for their livelihoods. This suggests that a large portion of agricultural activities are economically inefficient at present and that policy reforms and investments to improve irrigation systems and cropping techniques and diversify markets are required to develop the livelihoods of farmers residing around the Tonle Sap Lake and Cambodian Mekong River.

Acknowledgements

The authors are grateful to the Ministry of Economics and Finance, and the Ministry of Education, Youth and Sports in Cambodia for financial support. Sor Ratha also received support from the Wonders of the Mekong Project funded by the USAID.

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