DNIPRO STATE AGRARIAN AND ECONOMIC UNIVERSITY
MINISTRY OF EDUCATION AND SCIENCE OF UKRAINE

Qualifying scientific work on manuscript rights

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DISSERTATION

IMPROVING CONTRACT FARMING FOR FAMILY FARMS MANAGEMENT IN THE CONTEXT OF AGRICULTURE SUSTAINABLE DEVELOPMENT IN THE REPUBLIC OF MALDIVES

Specialty – 073 Management
Field of knowledge – 07 Management and Administration

Applied for the Doctor of Philosophy (PhD) degree

The dissertation contains the results of own research. The use of ideas, results, and texts of other authors are linked to the corresponding source

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The dissertation is identical to other copies of the dissertation

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ABSTRACT

Abdulla N. Improving contract farming for family farms management in the context of agriculture sustainable development in the Republic of Maldives. – Qualifying scientific work on manuscript rights.

The dissertation for the degree of Doctor of Philosophy in specialty 073 "Management" (07 "Management and Administration"). – Dnipro State Agrarian and Economic University, Dnipro, 2023.

The dissertation studies are dedicated to the theoretical and methodical substantiation and development of practical recommendations for improving the management of contract family farming in sustainable agriculture development in the Republic of Maldives.

The problem of advanced management is of great importance in any business activity because the major indicators – the net profit and efficient use of available resources – depend on how well the management process is carried out. Sustainable allocation of resources and cost-efficient strategies paired with maximal output are invaluable as they affect the profit, competitiveness, and whether the business activity can remain economically viable in the market. Similarly, resource management and production optimization are crucial factors in the agriculture, and this is the same for family farming communities. Being prevailing agricultural units in the world, family farms operate in a dynamic risky environment when providing own livelihood and employment and contributing to the national food security complicated by the rapid population growth, climate change, natural disasters, global shocks and crises.

The purpose of the dissertation is the theoretical and methodical substantiation as well as practical recommendations for elaborating improvements of management applicable to contract family farming in the Maldives on the way to sustainable agriculture. The research object is the process of improving contract farming for family farms management in the context of agriculture sustainable development in the Republic of Maldives. The research subject is the theoretical-methodical and scientific-practical

aspects of improving contract farming for family farm management in the context of agriculture sustainable development in the Republic of Maldives.

On the stage of substantiating fundamental bases in understanding and generalizing characteristics of the Maldivian family farms including a household size, income, a prime activity purpose, and resource limitations compared to those in other world economies, the research resulted in clarifying a definition of the category "sustainable family farming". It implies accomplishing eco-friendly resource-saving farming methods which bring farmers tangible economic advantages and are socially attractive for farming communities. Systematic theoretical analysis disclosed that the latter benefit from implementing a contract farming model which intertwines with strengthening food security and boosting rural development. The centralized contract farming model, launched by Agro National Corporation in the Maldives, should have a positive impact on effectiveness and efficiency of Maldivian agriculture where the implemented contractual agreement stipulates supplying inputs, transmitting advanced farming practices, ensuring credits and loans, monitoring crop quality, and arranging sales of harvests produced by the contract family farmers. However, statistics showed that demonstrated outputs tend to be worse than expected. The study outcomes, stemmed from exploring the most promising and workable directions to bolster management of family farmers operating under this contract farming model, proposed to combine management consulting and agricultural extension services to maintain continuity and viability of rural communities through well-planned strategies of farming activities supported by customized recommendations, cutting-edge technologies, shared contemporary agricultural knowledge and skills meant to empower small family farmers when earning their living and addressing food insecurity in the Maldives.

On the stage of analytical evaluation of the Maldivian nutrition security status and statistical comparison of agricultural development dynamics in the Maldives the research findings allowed to set a concept of an improved farm management process that incorporated a holistic approach to how to deal with the social, economic, and

environmental challenges faced by the local family farmers. The presented concept comprises a rational use of restricted natural resources, enhancing consulting on growing, harvesting and trading crops, and also recruiting and retaining farmers while a special emphasis is placed on fostering women and young people to get involved in sustainable farming activities. For this to happen, the study offered a systematic classification of core political, economic, social, technological, legal, and ecological factors observed in the Maldivian macro-environment that profoundly impact agricultural performance and decision-making in farm management, cause essential risks as well as help identify and seize beneficial opportunities arising in family farming. To narrow down and prioritize these challenges when moving away from outdated conventional farming, the research offers a complex organizational and methodical approach embracing cross-regional analysis, formal surveys, group discussions, personal interviews and further mathematical assessment of family farmers by age, gender, resource availability, climatic vulnerability, and market access.

On the stage of generating scientific results on how to improve family farm management for sustainable development of Maldivian agriculture, firstly, the study presented a way to address inefficient use of the available scarce resources and poor production which push the country towards high dependency on food imports. The proposed production optimization model calculates how to distribute land and labor and grow the most demanded and resource-efficient local fruits and vegetables in order to increase their harvests, raise welfare of the regional small family farmers, and amplify Maldivian food security that is consistent with the key goal of contract farming. Secondly, the research proved the methodical and organizational ways to improve agricultural consulting thorough eliminating passive attitude and covering a knowledge gap on promoting gender equity, reducing poverty, incentivizing leadership and entrepreneurship that were observed among extension officers involved in assisting contract farming. The study suggested training skills that are compatible with optimal region-specific production plans in order to ensure that family farmers are guided and supported from the point of

cultivation to the stage of outreaching potential markets. Thirdly, the research inferred that developing labor force should envelop farmers' assistance via ICT integrated measures, mobile devices and online apps, and also consultations in person provided by agricultural extension officers who must utilize recommended optimal transport routes saving time and cost when visiting dispersed islands participating in contract farming. The revealed organizational approach revolves around transmitting advanced technologies and cutting-edge skills to female and young farmers to guarantee continuity and viability of family farming communities and fulfill their potential in providing food security and developing sustainable agriculture.

The practical significance of the obtained results lies in suggesting relevant recommendations acceptable for improving contract farming management in order to optimize resource allocation, increase crop production, revamp agricultural technologies, and enlarge incomes of family farms engaged in developing sustainable agriculture to move away from critical import dependency and nutrition insecurity experienced in the Maldives. The main results of the dissertation research are presented in 11 scientific publications with a total volume of 6.9 printed sheets where 4.84 p.s. belong to the author.

Keywords: family farms, agricultural sustainability, food security, contract farming model, farm management, agricultural production optimization, resources, consulting services, female and young farmers.

АНОТАЦІЯ

Абдулла Н. Удосконалення контрактного фермерства для управління сімейними фермами в контексті сталого розвитку сільського господарства Республіки Мальдіви. – Кваліфікаційна наукова робота на правах рукопису.

Дисертація на здобуття ступеня доктора філософії за спеціальністю 073 "Менеджмент" (галузі знань 07 "Управління та адміністрування"). – Дніпровський державний аграрно-економічний університет, Дніпро, 2023.

Дисертаційні дослідження присвячені теоретико-методичному обґрунтуванню та розробці практичних рекомендацій для вдосконалення менеджменту контрактного сімейного фермерства в контексті сталого розвитку сільського господарства у Мальдівській Республіці.

Проблема вдосконалення менеджменту має вагоме значення для будь-якої моделі бізнесу, адже головні індикатори – чистий прибуток та ефективність використання наявних ресурсів – залежать від того, як добре здійснюється процес управління. Сталий розподіл ресурсів та витратно-ефективні стратегії разом з максимальним виходом продукції впливають на прибуток, конкурентоспроможність та визначають, чи може бізнес-діяльність залишатися життєздатною на ринку. Так само ресурсний менеджмент і оптимізація виробництва є вирішальними чинниками в сільському господарстві та зберігають своє значення і для сімейного фермерства. Як найбільш поширена форма господарювання в сільському господарстві, сімейні ферми функціонують у динамічному ризиковому середовищі, частково забезпечують себе засобами виробництва, створюють джерело доходу для родини та є місцем працевлаштування. Разом з тим вони роблять суттєвий внесок у продовольчу безпеку країн. Процес їх діяльності ускладнюється факторами приросту населення, зміни клімату, природними катастрофами та глобальними кризами.

Метою дисертації є теоретико-методичне обґрунтування і практичні рекомендації для покращення менеджменту, який може бути застосованим у контрактному сімейному фермерстві в Мальдівах на їх шляху до сталого сільського господарства. Об’єктом дослідження є процес удосконалення контрактного фермерства для управління сімейними фермами в контексті сталого розвитку сільського господарства у Мальдівській Республіці. Предметом дослідження є теоретико-методичні та науково-практичні аспекти удосконалення контрактного фермерства для управління сімейними фермами в контексті сталого розвитку сільського господарства у Мальдівській Республіці.

На етапі обґрунтування фундаментальних основ розуміння та узагальнення характеристик сімейних ферм на Мальдівах, включаючи розмір домогосподарства, дохід, головну мету діяльності, ресурсні обмеження, порівняно з іншими світовими економіками, результатом дослідження стало уточнення поняття “стале сімейне фермерство”, яке передбачає застосування екологічно чистих ресурсозберігаючих технологій, які приносять фермерам суттєві економічні переваги та є соціально привабливими для фермерської спільноти. В результаті системного теоретичного аналізу було встановлено, що фермери виграють від впровадження моделі контрактного фермерства, що сприяє посиленню продовольчої безпеки та стимулює розвиток сільських територій. Передбачалося, що модель централізованого контрактного фермерства, започаткована Агро Національною Корпорацією в Мальдівах, буде мати позитивний вплив на дієвість та ефективність сільського господарства Мальдів. Впроваджені контрактні угоди забезпечать постачання засобів виробництва, поширення новітніх аграрних технологій, гарантування кредитів і позик, моніторинг якості вирощуваних культур та організацію продажу врожаїв, зібраних законтрактованими сімейними фермерами. Проте, статистика показує, що одержані результати часто гірші за очікувані. У результатах дослідження стосовно найбільш перспективних та дієвих напрямів поліпшення менеджменту сімейних фермерів, які працюють за контрактною моделлю, пропонується об’єднати управлінський консалтинг та сільськогосподарські дорадчі послуги задля стійкості сільських громад через ретельно сплановані стратегії фермерської діяльності, підтримані індивідуальними рекомендаціями, передовими технологіями, поширенням сучасних аграрних знань і навичок, які мають розширити можливості малих сімейних ферм, підвищити рівень їх доходів, сприяти добробуту та вплинути на вирішення проблеми продовольчої безпеки в Мальдівах.

На етапі аналітичної оцінки стану продовольчої безпеки і визначення показників розвитку сільського господарства Мальдів результатом дослідження

стала концепція удосконаленого процесу управління, який включає цілісний підхід до вирішення соціальних, економічних та екологічних викликів, з якими стикаються місцеві сімейні фермери. Представлена концепція включає в себе раціональне використання обмежених природних ресурсів, покращення консультацій щодо вирощування, збирання та збуту врожаю, а також залучення та утримання фермерів в контрактній моделі, причому особливий акцент робиться на заохоченні жінок та молоді до сталого фермерства. Для досягнення цієї мети запропоновано удосконалити класифікацію основних політичних, економічних, соціальних, технологічних, правових та екологічних факторів макросередовища Мальдів, які докорінно впливають на продуктивність сільського господарства та прийняття рішень в управлінні фермами, викликають істотні ризики, а також допомагають встановити та використати корисні можливості для сімейних ферм. Для вдосконалення організаційно-методичного підходу під час переходу від застарілого традиційного землеробства до моделі сталого розвитку, запропоновано використовувати інструменти міжрегіонального аналізу, офіційні опитування, групові дискусії, особисті інтерв'ю та подальшу оцінку сімейних фермерів за віком, статтю, наявність ресурсів, кліматичною вразливістю і доступом до ринку.

На етапі отримання наукових результатів щодо покращення управління сімейними фермами для сталого розвитку сільського господарства Мальдів, по-перше, визначено підхід до вирішення проблеми неефективного використання обмежених ресурсів і недостатнього обсягу агровиробництва, які штовхають країну до високої залежності від імпорту продовольства. Запропонована модель оптимізації виробництва, яка дозволяє оптимізувати використання земельних і трудових ресурсів та вирощувати найбільш затребувані та ресурсоощадні місцеві фрукти та овочі, що збільшить їх виробництво, підвищить добробут малих фермерів та посилить продовольчу безпеку Мальдів, що відповідає головній меті контрактного фермерства. По-друге, обґрунтовано організаційно-методичні підходи до вдосконалення сільськогосподарського консультування шляхом

усунення пасивного ставлення і прогалин у знаннях консультантів щодо гендерної рівності, зменшення бідності, стимулювання лідерства та підприємництва. Запропоновано розвиток навичок, які відповідають оптимальним виробничим планам для конкретного регіону, щоб забезпечити супровід та контроль сімейних фермерів від моменту вирощування до етапу потрапляння зібраного урожаю на потенційні ринки збуту. По-третє, в результаті дослідження ми прийшли до висновку, що для розвитку сімейних ферм потрібно впроваджувати сучасні інформаційні технології, інтегровані в мобільні пристрої та онлайн-додатки. Фахівцям дорадникам рекомендовано користуватися такими технологіями, а також при наданні особистих консультацій оптимізувати транспортні маршрути для заощадження часу і коштів на відвідування віддалених островів, чиї громади беруть участь у контрактному фермерстві. Зазначений організаційний підхід спрямований на поширення новітніх технологій і передових навичок насамперед серед жінок і молодих фермерів, щоб гарантувати наступність поколінь і життєздатність сімейних фермерських спільнот та реалізувати їхній потенціал у забезпеченні продовольчої безпеки і розвитку сталого сільського господарства.

Практичне значення отриманих результатів полягає у розробці рекомендацій щодо вдосконалення управління контрактним фермерством з метою оптимізації розподілу ресурсів, збільшення врожаю, оновлення агротехнологій та підвищення доходів сімейних ферм, які сприяють розвитку сталого сільського господарства задля відходу від критичної імпортозалежності та посилення продовольчої безпеки Мальдів. Основні результати дисертаційних досліджень представлено в 11 наукових публікаціях загальним обсягом 6.9 друкованих аркушів, з яких 4.84 д.а. належить авторці.

Ключові слова: сімейні ферми, стале сільське господарство, продовольча безпека, модель контрактного фермерства, управління фермерськими господарствами, оптимізація аграрного виробництва, ресурси, консультаційні служби, жінки та молоді фермери.

LIST OF PUBLISHED WORKS ON THE THEME OF THE DISSERTATION

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1. **Abdulla N.,** Vasylieva N., Volovyk I. Key regional problems of the contract farming in the Republic of Maldives. *Modern Economics*. 2022. 35, 6–12. DOI: https://doi.org/10.31521/modecon.V35(2022)-01 (0.8 p.s. *Personal contribution of the author: assessed and explained the resemblances and differences observed in the key agricultural regions in the Maldives regarding gender disparity, farming population age, access to land, markets, and finance, 0.27 p.s.*)

2. **Abdulla N.,** Vasylieva N., Volovyk I. On improvements of agricultural extension services for contract farming. *Агросвіт*. 2023. 3–4, 33–42. DOI: https://doi.org/10.32702/2306-6792.2023.3-4.33 (1.1 p.s. *Personal contribution of the author: specified contract farming models and clarified means to improve agricultural extension services through optimal routes when consulting family farmers in person and assisting their activity via mobile devices and online apps, 0.37 p.s.*)

3. Abdulla N. Agricultural production and import targets for farming development in the Maldives. *Ефективна Економіка*. 2023. 3, 20 p. DOI: https://doi.org/10.32702/2307-2105.2023.3.56 (1 p.s.)

4. Abdulla N. Sustainability of Family Farms in the Maldives: Influence Factors and Challenges. *Агросвіт*. 2023. 7–8, 124–134. DOI: https://doi.org/10.32702/2306-6792.2023.7-8.124 (1.3 p.s.)

An article in a periodical scientific edition, indexed in the databases Web of Science Core Collection and Scopus

5. **Abdulla N.,** Vasylieva N., Volovyk I. Production optimization for sustainable agriculture and efficient contract farming in the Republic of Maldives. Bulgarian Journal of Agricultural Science. 2022. 28(4), 579–590. DOI: https://doi.org/10.5281/zenodo.7620892 (1.3 p.s. *Personal contribution of the author: proposed and calculated production optimization model with region-specific optimum*

crops to allocate resources, minimize expenditures and increase harvests recommended to family farmers involved in contract farming in the Maldives, 0.5 p.s.)

Scientific publications which confirm approbation of the dissertation materials

6. Abdulla N. Project Approach on Enhancing Sustainable and Environmental Smart Fertilizer Usage in Agriculture of the Republic of Maldives. Тези доповідей науково-практичної конференції молодих вчених і студентів *"Молоді науковці аграрники: традиційні й нові аспекти досліджень"*. 2020. Дніпро: Друкарня "Стандарт", 92–94. (0.15 p.s.)

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11. Abdulla N. On Improvements of Family Farming Management in the Republic of Maldives. Proceedings of the VII International scientific and practical conference *"Scientific progress: innovations, achievements and prospects"*. 2023. Munich: MDPC Publishing, 467–468. (0.1 p.s.)

CONTENT

INTRODUCTION

Relevance of the research topic. Family farms are the dominant form of farming all over the world where their activities support food security and rural development in terms of employment opportunities, income, and infrastructure while safeguarding the environment and culture. Similarly, in the Maldives, family farms contribute to food production and ensure the livelihood of the farming population. These topics were profoundly explored by numerous scientists including J.P. Aryal, H. Baliwada, R. Bezus, M.L. Blum, P.M. Bosc, M.P. Farran, E. Garner, M.Y. Malik, V.A. Mamchur, S.J. Reyes, O.H. Shpykuliak, and H.V. Spaskyi who specifically studied the characteristics of different family farms observed across different nations and how effective they are in employing their resources and fulfilling production potential.

Contemporary studies show that by 2050, South Asia's population will amount to over 5 billion people, who will require 20% more agricultural products to offset the increase in food demand which further amplifies the importance of family farms in the agricultural sector. This issue was researched by M.R. Bari, C. Daugbjerg, K.E. Giller, R.Q. Grafton, N.M.A. Manap, D.M. Van, N. Vasylieva, A.S. Wesley, J. Woodhill, Z.Y. Zhou, and many other scientists who focus on understanding the challenges and ways when maintaining food and nutrition security. Scholars argue that the latter is linked to sustainable agriculture which is based on the combined development of economic, social, and ecological components to meet the present needs without compromising similar requests and opportunities of future generations in this area. Such a concept was fundamentally explored by M.J. Antle, J.P. Aryal, N.R. Khalili, E. Lighthouse, R.S. Meena, O. Pavlenko, S. Ray, J. Uziak, S.S Walia, U.S. Walia, G.M. Whiteman, and others whose findings were about encouraging, expanding, and implementing farming that acknowledges economic profitability, social equity, and environmental health.

Recent complex studies by D.K.S. Behera., M.F. Bellemare, A.T. Melese, K. Otsuka, M. Qaim, M. Rankin, A. Ruml, C.A.D. Silva, G. Ton, M.A. Will substantiate that

being successful and popular among different nations, the contract farming model is a workable solution for farmers to elevate their productivity, get access to cutting-edge agricultural technology, and reduce sales risks. This approach is a win-win situation for both involved parties, since under these contractual agreements the farmers are assured of the return of their investments in harvested crops and the buyers receive a quality agreed quantity of produce that prevent market failures.

To run a farm enterprise, farmers need to select, organize, and conduct an individual farm business for the purpose of obtaining the greatest possible profit. J. Boucher, R. Daniel, P. Duffy, W. Edward, C. Hassey, R. Kay, P.L. Nuthall, K. Olson, G.O. Stephenson, I. Volovyk, and J. Westra carried out comprehensive studies which gave insight into detecting and finding the advanced methods of planning, arranging, monitoring and controlling in farming in order to increase efficiency and mitigate uncertainty caused by decision-making in farm management.

New challenges from practice including accelerated population growth, climate change, global crises like war conflicts and pandemic restrictions emphasize urgent open questions which should be addressed by further scientific studies. In particular, the Maldives struggles with crucial dependence on food imports and nutrition insecurity, devastating natural disasters which affect the local agriculture weakened by land and water scarcity and outdated conventional farming technologies. Given this, the dissertation research topic focuses on improving management of the Maldivian family farms through the contract model to achieve sustainable agriculture.

Connection of the thesis with scientific programs, plans, and topics. The study was carried out within the framework of scientific research approved by the Ministry of Education and Science of Ukraine. The dissertation work was agreed with the initial topic of scientific research work of the Department of Management, Public Management and Administration of the Dnipro State Agrarian and Economic University “Development of management consulting and advisory services to strengthen the competitiveness of agricultural enterprises and ensure balanced development of socio-economic systems at

the regional and local levels" (2021–2025, state registration number 0121U009893) and performed in compliance with the individual plan of the educational and scientific program for the Doctor of Philosophy in Management.

The purpose and tasks of the research. The purpose of the dissertation is the theoretical and methodical substantiation as well as practical recommendations for elaborating improvements of management applicable to contract family farming in the Maldives on the way to sustainable agriculture.

To achieve this goal, the following tasks have been set for research:

- to generalize categorical definitions and combine theoretical approaches to determining the meaning of sustainability in family farming (1.1);
- to classify and compare contract farming models and analyze general features of the AgroNAT contract farming model implemented in the Maldives (1.2);
- to find out the most promising and workable direction to improve farm management in the Maldivian contract farming (1.3);
- to evaluate Maldivian food and nutrition security status and assess dynamics of agriculture development in the Maldives (2.1);
- to investigate external macro-environmental factors that may profoundly impact agricultural performance of the Maldivian family farmers (2.2);
- to explore observed resemblances and differences between agricultural regions in the Maldives which are involved in contract family farming (2.3);
- to clarify the ways to improve the production management of the family farmers through the optimal allocation of lands and crops (3.1);
- to reveal how to revamp agricultural extension services provided for small family farmers who participate in contract farming (3.2);
- to identify measures to develop labor force in contract farming and the ways to address gender and age disparity in farming communities (3.3).

The research object is the process of improving contract farming for family farms management in the context of agriculture sustainable development in the Republic of Maldives.

The research subject is the theoretical-methodical and scientific-practical aspects of improving contract farming for family farms management in the context of agriculture sustainable development in the Republic of Maldives.

Research methods. The methodological foundation of the performed research is based on the scientific achievements and developments of the world scientists, especially those from South Asia and Ukraine, regarding the problems of improving the management of the contract farming model when moving farms towards sustainable development. To achieve its objective, the research study used a complex of general and special scientific methods. The historical abstract and logical method was employed to generalize fundamental definitions of "contract farming," "family farms," "management", and "sustainability" based on the features of family farming in the Maldives. Systematization and scientific comparison were utilized to identify peculiarities of the family farming communities in three regions and clarify the internal and external factors affecting farming activities in these rural areas. Observations, interviews, and farmer interactions such as formal and focus group discussions were used to explore the challenges the farming communities face and how they distribute resources to reach set targets. Methods of statistical analysis and graphic visualization were utilized to present illustrations about Maldivian agriculture. A mathematical method of optimization modeling was used to identify the most profitable crops to grow by regions and the optimal routes for reducing logistical costs when providing consulting services. All the information collected through primary and secondary data sources was processed to achieve the objective of the dissertation by employing modern software, in particular Google Sheets, Google Forms, and the tool Solver, built into the MS Excel.

The scientific novelty of the obtained results manifests itself through development of the theoretical and practical principles of improved management for

contract family farming aimed at providing food security and sustainable agriculture. In particular:

acquired further development:

the conceptual-categorical apparatus when interpreting "sustainable family farming" as working towards sustaining farmers, resources, and the farming communities by pushing towards more profitable and environmentally friendly agricultural practices and by fitting and revamping conventional ways of farming with new modern agricultural methods applicable to farming activities which are a primary source of farmers' nutrition and livelihood. This definition takes into account key features of the Maldivian agriculture on the way to food security and rural development; (1.1)

the scientific grounding of objectives, areas, monetary benefits, and non-monetary advantages which accompany implementation of the Centralized contract farming model that contributes to improving effectiveness and efficiency of Maldivian agriculture. It allows to evaluate how successful the state-owned company-initiator AgroNAT is in supporting the whole process of farming from sowing to harvesting crops in order to guarantee a fixed quantity and production quality and push the small family farmers toward economic, social, and environmental sustainability; (1.2)

an organizational and methodical approach to improve farm management in contract farming which offers to combine management consulting and agricultural extension services. It would ensure continuity and viability of rural communities through complex professional expertise, strategic plans of farming activities, customized recommendations on implementing advanced technologies, and sharing cutting-edge knowledge and skills for empowering small family farmers to enlarge their incomes and increase their contribution to the food security in the Maldives; (1.3)

a general concept which considers farm management improvements as a holistic approach which has to address economic, social, and environmental challenges that small family farmers meet on their way to sustainable agriculture. It implies appropriate planning, organizing, and controlling measures presented by means of rational use of

limited natural resources, advanced agricultural consulting services, and labor force enhancement with a special focus on female and young farmers to overcome food and nutrition insecurity; (2.1)

a systematic classification of external macro-environment groups of factors having essential impact on sustainable agriculture development. It was based on PESTLE analysis that allowed to identify key political, economic, social, technological, legal, and environmental factors observed in the Maldives which should be addressed via improved farm management as potential challenges and future beneficial opportunities for successful small family farming; (2.2)

an organizational approach to how to develop labor force, transmit knowledge, skills, and provide requested consultations for small family farmers. It utilizes ICT integrated measures (text and multimedia mobile messages and online specific apps) and personal meetings with AES officers who should follow the calculated model transport route optimizing the time and money spent on reaching dispersed rural areas. The offered approach makes special stress on encouraging female farmers to address gender inequality and reinforce food security as well as on engaging young farmers who can most contribute to the development of sustainable agriculture; (3.3)

improved:

an organizational and methodical approach to the cross-regional analysis of human resources by age and gender, available land, supply of inputs, vulnerability to climatic instability, finance, and market access that enables to pinpoint inconsistencies and variances across regional farming communities through field visits, questionnaire-based survey, informal focus group discussions, face-to-face interviews and further mathematical analysis of the collected data. The offered complex approach is focused on enhancing the contract farming model to move away from the aged farming population who sticks to the conventional agricultural method with poor production capacity to young, motivated farmers equipped with technological skills and contemporary knowledge; (2.3)

a production management optimization mathematical model for family farmers who participate in contract farming was formulated and calculated regarding Maldivian agricultural capacity and natural resource constraints. In this context, the model included the most demanded crops based on the import figures, available land areas, target harvests, and financial limits of expenditures covered by AgroNAT and distributed among the three operating farming regions. The developed model put forward plans how to improve the management of family farming communities and raise farmers' incomes by means of the proposed most economical, resource-efficient crop allocations that ensure the yields with higher quality and quantity compared to the existing cultivation choices practiced by the local small family farmers; (3.1)

a methodical approach to identifying and covering the knowledge gap in AES officers' skills and qualifications in the region-specific areas of planning farm activities, field management, harvesting procedures, and marketing issues for the most demanded crops which are consistent with optimal production plans by regions of contract farming, aimed at improving rural livelihoods and implementing advanced technologies of sustainable agriculture. (3.2)

The practical significance of the obtained results incorporates development of practical recommendations related to improving contract farming for family farms management in the context of agriculture sustainable development in the Republic of Maldives.

The research findings concerning optimization modeling and training program development were implemented at the Agro National Corporation (the Republic of Maldives), the certificate dated September 19, 2023.

The practical value of optimization model approach and survey conducting were both implemented for the training program in Dnipropetrovsk Agricultural Advisory Service, NGO (Dnipro, Ukraine) and Rural Women Business Network, NGO (L'viv, Ukraine). Both certificates dated September 15, 2023.

Scientific and methodical research findings were implemented for courses "Management Consulting and Advisory Activities", "Project Management", and "International Economy" at the Dnipro State Agrarian and Economic University (certificate 0002549 dated September 11, 2023).

Personal contribution of the author. The author substantiated theoretical and methodical principles and practical recommendations regarding improving contract farming for family farm management in the context of agriculture sustainable development in the Republic of Maldives. The author herself obtained the scientific results presented in the dissertation work. From the scientific works published in co-authorship, only those ideas and provisions resulting from the author's personal achievement were used.

Approbation of the dissertation results. The main research findings and outcomes were made public and got tested at 6 conferences such as: the scientific and practical conference of young scientists and students "Young agrarian scientists: traditional and new aspects of research" (February 25–28, 2020; Dnipro, Ukraine); the VIII scientific and practical internet-conference "Development of forms and methods of modern management in conditions of globalization" (November 2–6, 2020; Dnipro, Ukraine); the II Ukrainian scientific and practical online conference "A young modern scientist as the foundation of development of education, science and business in Ukraine" (November 25, 2020; Dnipro, Ukraine); the XV intercollegiate scientific and practical conference "Preparation of specialists on the way to European integration: problems and prospects" (April 15, 2021; Dnipro, Ukraine); the 5th International scientific and practical conference "Scientific Trends and Trends in the Context of Globalization" (February 19–20, 2023; Umea, Sweden); the VII International scientific and practical conference "Scientific progress: innovations, achievements and prospects" (April 3–5, 2023; Munich, Germany).

Publications. The main results of the dissertation research are covered in 11 scientific publications of the total volume of 6.9 printed sheets (4.84 p.s. belong to the

author). These are 1 article in the journal indexed in the databases Web of Science Core Collection and Scopus (0.5 p.s. belong to the author), 4 articles in the journals from the list of professional editions of Ukraine (2.94 p.s. belong to the author), 6 materials in the conference proceedings (1.4 p.s. belong to the author).

Structure and scope of the dissertation work. The dissertation work for obtaining the degree of the Doctor of Philosophy consists of an introduction, three chapters with conclusions, final recommendations, and references. The total volume of the work is 204 pages. The main text occupies 166 pages and contains 19 (4+4+11) tables (in particular, 1 full-page table) and 20 (2+12+6) figures (in particular, 1 full-page figure). The list of used sources comprises 188 titles.

CHAPTER 1.
THEORETICAL BASES TO IMPROVE MANAGEMENT IN CONTRACT FARMING FOR SUSTAINABLE DEVELOPMENT

1.1. Definitions of family farms and the concept of sustainable development

Family farming is a broad concept encompassing culture and tradition. There are more than 570 million farms worldwide [170]. According to the Food and Agriculture Organization of the United Nations (FAO), family farmers are the predominant part of world agriculture, where more than 500 million farms are controlled and managed by families. There is no specific definition for family farms [50]. However, this concept is based on certain principles where family farming can be defined as agriculture, forestry, and fisheries activities carried out and managed by a family where the whole operations of these activities rely on the members of the family as the primary source of labor where the continuity of the farms entirely depends on inter-generational succession [178].

Family farmers are also defined as family members who rely solely on agricultural activities and sometimes operate as smallholders to large farm owners. This business depends on family members as the labor force, including men and women [141]. Overall, the whole concept of the family farm is based on four dimensions, embracing the share of farm labor, succession between generations where the entire business is controlled and owned by the family members, no legal status, and the family itself bears the risks of the farm business.

Most family farms are operated on lands inherited over generations, where farmers work full-time and part-time. In most cases, these farmers function without any income where the product is used for consumption [178]. There are three categories of family farms. There are: 1) family farmers, who have no access to finance to scale up their business, but they are well established and integrated into the market; 2) farmers who have no infrastructure, no capital which makes them eligible for any credit or loan schemes; 3)

poor farmers who have no access to market and inputs and are only able to produce bare minimum amount to meet their daily requirements [98], [99].

According to the substantial definition, family farming means organizing and managing farming activities by family members where it depends on family members as the primary source of labor and where the family farms co-exist and co-evolve with the economic, environmental, social, and cultural functions. The statistical definition of family farms describes family farms as agricultural holdings organized and controlled by households [19], [28].

Family farms range from family forms to entrepreneurial and business conditions. In the entrepreneurial form, the land is owned by indirect formal tenure, where the farm is managed and organized technically, and the production is targeted to the market. In the business forms, the family farms capitals are family associations that arrange and manage farm activities. The production, by this form of farms, is mainly used for consumption, and the leftover is sold. Compared to these two forms of farming, a family form of agriculture is organized and managed by the family members, and the production is consumed to meet the daily requirements of the family [19].

Numerous descriptions of family farms by different authors clearly show essential distinctions. Nevertheless, almost all the definitions share some common features in describing the primary forms of family farms, such as the origin of production, decision-making methods, and legal status. In other words, regardless of the economic situation of a nation, all the definitions of family farms are based on four analytical criteria: labor force, land tenure, size/equipment, relationship with markets, integration in the local community, and relations with global societies [79].

Different definitions proposed by different authors are discussed to understand the concept of family farms. The purpose is to understand and identify the main aspects of family farming regarding agricultural production and rural transformation. These definitions are put forth by different authors, government, and non-government organizations to study family farm activities.

A research study by C. Toulmin and B. Guèye to understand the basis of the challenges faced by the family farming communities compared the difference between family farms and commercial agriculture to elaborate and understand family farmers. The authors describe them in social-cultural, economic, and technical dimensions. Firstly, it means that these farms depend on family members as their main source of labor. Family farming activities are strongly connected with the community regarding relationships and strategies where they have a collective commitment and mutual relationship. Secondly, family farms are defined as producers of crops where they gain an economic benefit by selling their products depending on the availability and accessibility of the market, where the rest of the production is consumed and stocked. Finally, the technical dimension outlines family farmers as farmers who carry out highly diversified farming activities and use the maximum available land resources, which range mainly from 5 to 10 hectares, to reduce risks. They acquire the land through family and social inheritance [164].

L. Cotula, C. Toulmin, and J. Quan researched the importance of family farming activities and their connection to land access in poverty reduction. This study determined family farms as farming activities carried out by family members to provide food security to society and the source of employment and income generation. The authors argue that family farming activities sustain rural communities, including crop production, livestock rearing, and other activities to produce food using natural resources, which are also very important for the livelihoods of the whole society [49].

Study carried out by E. Garner and A.P. Campos on identifying family farms its concepts and definitions states that I. Iwamoto identifies family farms as “well-organized members involved in family relations where they manage their farm activities as a family, acting as investors and owners deeply rooted and tied to their society. These farms are also passed down to the family as inheritance and contribute to the nation's livelihoods” [67, p. 26].

A research study carried by M. Ahearn, K. Poppe, C. Salvioni, et al. to determine whether family farms will continue to dominate agricultural production in the future

defines family farmers as small entities organized together as a family-supporting group with land, labor, and capital and carrying out their activities as a business. It was proved that in some parts of the world, family farming has become a dominant determinant of rural communities where family farmers form the normative and political force of the community. According to these authors, the way family farmers acquire capital and human resources has changed over the years, including renting capital, land, and outside labor. Though these realities are different, the reward of this small entity or group depends on family farm income from their collective activity [15].

M. Ahearn, K. Poppe, C. Salvioni, et al. formulated that family farms are small family-based operations that can address the community's unemployment issue, face poverty, and have the capacity to intensify production. These researchers stated that for family farms to flourish, they must get miscellaneous help to manage their natural resources, which are impacted by the growing population of the communities. The scientists highlighted that family farmers influence society's economic, social, and environmental well-being [15].

FAO report on the consultation on the innovation system of family farms in 2012 describes them as social and economic sectors run by families that use their members as the main source of labor. This report also categorizes the family-based agriculture sector into subsistence farmers and a sub-sector with fewer farms. The subsistence farmers carry out farm activities but depend on other income sources, including non-farm employment, remittance, and cash and in-kind social welfare support. The second category is about commercialized farms, and hence based on the discussed definition, family farmers are rural farmers who produce for consumption and where the consumption leftover is used for economic purposes [35], [142].

The Food and Agriculture Organization's study on identifying and defining family farms in 2014 outlined specific characteristics of family farms. It focused on family farming in terms of family and community aspects for rural development and production objectives. Firstly, family farmers as a family is a unit of community with local knowledge

and social ties and who have a common understanding and support in rural areas. Secondly, these family farmers are considered the backbone of the society, which directly impacts the community's social, economic, and environmental spheres where they directly influence and impact. Finally, regarding production family farmers are the pillar of society that provides food and nutrition security for the whole nation [66].

According to P.M. Bosc, J. Marzin, J.K. Belieres, et al., family farms are characterized as a group of farmers living in rural areas where the farming activities from production to management are carried by family members and depend entirely on family members as their main source of labor. The major income of the family farmers depends totally on a combination of revenue from agricultural and other non-agricultural activities. However, family farmers are the prime suppliers of society who contribute to managing the environment and biodiversity [41].

H. Baliwada wrote that family farms are operated and managed by families where the main source of labor is family members, including men and women. Thus, the family farm encompasses food production, income generation, equity, entrepreneurship, and the environment. It is the predominant form of agriculture in the food sector, where they interact with the community's natural resources and sustain them [28].

According to the definition by FAO and IFAD in 2019, family farmers are small groups of rural people who are interconnected as producers, family members, owners, and managers of farm activities where traditional knowledge, innovative farming solutions, the past, present, and future are all deeply intertwined. Both men and women are involved in farming and are the major investors in the agricultural sector. The analyzed definition says that family farmers can address the world food and nutrition security with sufficient support and management strategies as they produce enough to deal with the world hunger. Nevertheless, their produce goes to waste without reaching the market [61].

C.E. Perpetua, C.O. Uchenna, J.O. Ngozi, and O.O. Ebere in their assessment study on women's participation in family farming, offered to consider family farming as an organized group of people connected by family bonds where it excludes hired labor. As a

production unit, it depends on family members as their main source of labor, where assets, markets, and operations are shared among the family members. They collectively choose production, consumption, investment, and accumulation. The loss and reward are also shared among the members of the family farm [130].

Similar to these descriptions proposed by different authors, other forms of farming are also observed. Apart from family forms of agriculture, there are entrepreneurial and business forms of farming. In the entrepreneurial form, the laborers are paid employees and production is carried only for the market. In business forms, the work depends on either family or family association and is controlled by family or special technical expertise. Unlike business forms, entrepreneurial forms strictly require technical and land monitoring. The business is either direct ownership or indirect formal tenure. In the business form, the production is used for the market, whereas the residual is used for consumption [131].

Leaving aside the entrepreneurial and business conditions of farming, this Ph.D. research will look into the family farming behavior and characteristics of different nations to understand how it relates to the economic status of these nations. In the USA, family farms are considered family farms if owned only by family members, in a partnership, or in sole ownership. In this regard, if hired managers manage the business, it cancels the family farm status [168]. In the USA, family farms are categorized into three main groups based on annual turnover. The largest group of family farmers falls into the category of farmers who earn up to $250000 of gross annual sales. The minority of family farmers consist of farmers with an annual sale of more than $500000. The rest of the family farmers fall into medium-sized farms [168]. The cooperative agribusiness model in Canada is more common in the agricultural sector, where 7% of the industry contains family farms.

Unlike the USA and Canada in Ukraine, the family farm is identified as a “family farming household” or a family farm as a form of private entrepreneurship. N. Vasylieva and H. James stated that Ukrainian family farms are represented by semi-subsistent rural

households and more commercially oriented family farms that produce staples for the domestic market. They contribute significantly to food self-sufficiency while their farming activities support the livelihood of more than 13 million people in rural regions of Ukraine. However, it is evident that annual production of these family farmers is unstable as they are primarily disadvantaged by poor financing and inadequate machinery, reflecting the importance of addressing these issues to provide food security and viability of farming communities [173].

Ukraine is a transitional economy, and the legal status of family farming is important as it helps them participate in government support programs, which motivate the family farmers to pay taxes. According to M.Y. Malik, O.H. Shphykuliak, and V.A. Mamchur, family farming is an entrepreneurial activity where the farming activities are carried out by the family members, motivated towards making profits and meeting family needs. According to these authors, by their very nature, family farms are represented in the market by their social progress and the level of gross agricultural production. This research study also states that family farms are a major part of the agricultural sector in Ukraine and contribute significantly to the national GDP [107]. Authors also emphasize the importance of managing the development of family farms to move the farms away from the “gray” farming towards business-oriented farming activities through economic, social, and environmental sustainability measures. As per the authors, to achieve this, family farmers must be given access to 2 to 50 or more hectares of the area and developmental support based on their specialization criterion with agricultural infrastructure and cutting-edge technologies [107].

H.V. Spaskyi concluded that successful family farming in Ukraine depends on balanced forms of farm management. The study further highlights the importance of supporting family agribusiness to enhance welfare of rural population and boost rural development of farming communities to achieve sustainability [150].

The definition of family farms varies between EU countries and transitional economies. In EU countries the family farm categorization is not only restricted to small

subsistence or to large oriented but ranges from the small subsistence to farms with large scale of capital investment where family members act as the main source of labor. Like other small family farmers, EU farmers are also faced with noticeable challenges. The EU has modified its agricultural policy, which led to the reduction of consumers and taxpayers in the agricultural sector, making it challenging to access farming credits along with the growing capital needs of the farmers. Land restriction is another issue faced by EU family farmers. Among the EU family farms, the land is passed down to the generation. This restricts young farmers from accessing land as their parents control the management of the farmlands. As a result, the aged farmer population is observed among the EU family farmers. Hence, these family farmers have faced the challenges of accessing agricultural credits paired with high land prices due to the density of the population and the demand for alternative land uses [173].

A study carried out on Latin American family farms distributes them into three types, which comprise rural households where family farms carry out farming activities and production for consumption only, family farms controlled by family members, with some farm capital and production used for consumption and residue used to gain revenue, and family farms which carry specialized farm activities and target a large proportion of production for a market while a small share of produce is used for consumption [22], [60]. Based on this, in Brazil family farms should only employ family members as laborers, and the farm must be managed by family members whose income predominantly depends on agricultural activities [60].

South Asian countries which fall under the developing country category comprise Afghanistan, Bangladesh, Bhutan, India, the Maldives, Nepal, Pakistan, and Sri Lanka, where 65% of the population resides in rural areas. Most of the people in these countries are smallholder family farmers adopting integrated farming systems consisting of agriculture, livestock, forestry, and fisheries [148]. These small family farmers produce 70% of the food in the region.

Agriculture in South Asian countries mainly depends on smallholder family farming, where 87% of these farms have less than 2 hectares of land in developing countries. The average size of a farm is very small and relies on the family as the primary source of labor. These family farms need access to information and are faced with coordination problems in the efficient delivery of inputs, financial arrangements, technical backstopping, and effective output marketing services. Most small families in rural areas are disadvantaged [61], [148].

The Maldives belongs to the South Asian group of countries where family farmers are characterized as poor, with limited access to markets and agricultural services [132]. Among all of the above definitions, those of FAO and IFAD [61] and H. Baliwada [28] best described the type of family farming communities observed in the Maldives, which outlines the core characteristics of the South Asian family farmers as given in Table 1.1.

Table 1.1

Key features of the South Asian family farming

Feature	Description
Labor force	Small family group
Land size	Less than 2 hectares of land
Ownership	Controlled by the head of the family
Purpose	The primary production goal is for consumption, the leftovers are used to gain economic benefits
Production issue	Inefficient delivery of inputs and investment

Source: compiled by the author based on [28], [148]

The listed characteristics and dimensions will be used as the essence of the “family farms” in this Ph.D. research to investigate family farming communities in the Maldives.

Family farming communities are vital in addressing world hunger and malnutrition. They are believed to be more productive and sustainable per unit of land and energy consumed [28]. The whole family farming concept links agricultural production to family members mobilizing family labor and distributing final consumption, intermediating it with investments and accumulation. FAO states that 80% of the world food is produced through family farming [137]. This reflects the significant role of rural communities in addressing world poverty and famine. The family farm business is the main driving force in generating income in rural areas, providing job opportunities, nutrition, and food security. Similarly, it is a central element in preserving landscapes and the cultural heritage of these communities [8], [13], [69].

All of the above shows that family farming plays a crucial role in achieving the agricultural sustainability of all nations, propagating communities in achieving the United Nations Sustainable Development Goals (SDG), which aims to end hunger, achieve food security, and promote sustainable agriculture [56], [165].

Sustainability is a core contemporary concept in managing firms via a holistic approach by combining firms' economic, environmental, and social dimensions. Sustainability depends on principles based on three pillars: economy, society, and environment. Some authors name these principles as profits, people, and the planet [180].

Three theories of sustainability attempt to prioritize and integrate social responses to environmental and cultural problems. This includes Corporate social responsibility, Stakeholder theory, and corporate sustainability. Corporate social responsibility underlines increasing awareness of social responsibility among businessmen and links social responsibility and economic performance. The Stakeholder theory prioritizes sustainable development and corporate sustainability to adapt and operationalize the concept of sustainable development in corporate contexts. Corporate sustainability further broadens the system boundaries by focusing on changing the policy environment for firms [139], [169].

There are opposite opinions about the priorities of economic and ecological components in the concept of sustainability. In particular, ecological analysts or system theorists consider energy flow and population dynamics. They highlight implementing strategies and actions that balance the social system for long-term survival, including redundancy and adaptability [55], [86].

Economic theorists underline the importance of steady per-capital income flow for long-term economic growth without deteriorating the environment where these theorists debated on how to sustain income flow and maintain the capital endowments. These debates further proposed weak, strong, and very strong sustainability theories. The weak sustainability theory argues for maintaining non-declining per capita human welfare over time by combining efficiency principles in development. This theory strongly argues the progress of science and technology with the substitutability of natural and manufactured capital with economic development. The weak sustainability theory is too optimistic about humans' ability and believes that ecosystem functions can be replaced [56], [139], [169].

The very strong sustainability theory emphasizes that the right to live of other species requires subsystems of the natural environment and every species to be preserved for present and future generations. Weak sustainability argues that the two types of capital are essentially interchangeable, whereas strong sustainability insists that natural capital is increasingly the scarcest factor of production. The advantage of strong sustainability is that the economic system is a subsystem of nature. The disadvantage of strong sustainability is that the role of technology is underestimated. This theory declares that natural capital is restrictive while some natural capital can be substituted [56], [139].

In these sustainable theories, the value is mainly based on three capital stocks: natural/the environment, social/society, and economic/the economy. However, there are different scientific opinions on whether these capitals can be interchanged or if natural capital should not be reduced [56], [139], [187].

Studies show that among 3 billion rural people in developing countries, 2.5 billion people belong to families engaged in farming, guaranteeing food and nutrition to two-

thirds of the world's population. Family farms ensure the welfare of the rural population by alleviating poverty, hunger, and malnutrition, providing employment opportunities, and protecting the biodiversity and conservation of local varieties [28].

In 2005, the United Nations General Assembly formulated 17 Sustainable Development Goals (SDG) from which many of the SDGs can be achieved through development of the agricultural sector. More than 6 SDG goals are directly and indirectly linked to sustainable agriculture, in particular, SDG (#2), which calls to end hunger, achieve food security and improved nutrition, and promote sustainable agriculture, which is directly linked to the SDGs about clean water and sanitation (#6), affordable and clean energy (#7), decent work and economic growth (#8), responsible consumption and production (#12). Indirectly, agriculture also impacts the community and income-based SDGs, addressing poverty (#1), education (#4), gender equality (#5), climate change (#13), and life on land (#15) [56], [165].

According to studies, family farming labor is responsible for at least 53% of the world's food supply, directly contributing to achieving the UN SDGs [165]. Hence, it is crucial to support the family farming communities toward more productive, profitable, and efficient allocation of resources, as well as public policies to assist and encourage farming activities. This reflects the importance of managing family farming communities on their way to sustainability.

"Sustainability" means improving the present generation's social and environmental performance without compromising the future's ability. Farming considers the economic, ecological, and social factors contributing to the succession and continuity of rural communities [45], [133].

According to the USA Farm Bill released in 1990, sustainable agriculture is a combined system of animal and plant production specific to a particular farming area, which will, over the long term, secure and satisfy human nutrients, sustain the natural resource base on which agriculture depends, increasing efficient utilization of non-

renewable resources, maintaining the economic viability of the farming and agricultural operation, enhancing the social and economic well-being of its operating society [168].

The UN Food and Agriculture Organization defines sustainable agriculture development as managing natural resources directing technological and institutional change to attain continuity in the satisfaction of human needs of the present and future generations [166].

The world's poorest countries' livelihood depends on agricultural activities. Food production is the main agricultural activity of small-family farmers in rural areas of Africa, Asia, and South America. There most of the population lives in poverty-stricken communities. Agriculture in developing countries is under constant pressure due to the fluctuating climate, degradation of the environment, and rapid growth of the population and economy [112], [170].

A recent study carried by J.P. Aryal, T.B Sapkota, R. Khurana, et al. on climatic change and the options in family farms production system of the South Asian countries reflects the vulnerability of the Maldivian farming communities to fluctuation of climatic conditions. In this work authors inferred that a comparatively small rise in global temperature could lead to submerging the dry land and contaminating the thin fresh water layer [23]. F. Shafeeqa and R.M. Abeyrathne explored farmers' adaptation in three communities in the Maldives where they also stressed by the potential loss due to the sea level rise which results in high salinity of the ground water unsuitable for farming purposes [147]. Similar conclusions concerning disaster risk reduction in the Republic of Maldives further affirmed this by proving the negative impact of climatic changes on farming communities and the economic activities [54]. Besides, more than 90% of the poor Maldivians lives in atolls away from the capital city. Therefore, the Maldives faced with persistent danger from climatic change which comprises more than 1192 islands is predicted to become inhabitable by the end of the 21st century owing to heavy severe floods [92], [117], [134].

Studies show that 90% of the atoll's population depends on rain as their primary source of drinking water. In addition, the Maldivian soil comprises a thin sandy layer with an organic matter of 15–40 cm deep and a hardpan of 30–50 cm deep before reaching bedrock [23]. Assessments about climatic change impact on the livelihood of rural island communities shed light on how the sea level rise could further exacerbate the decrease in available farmlands, where the agriculture remain the most important source of income and food security [46].

According to National Fisheries and Agricultural Policy, more than 50% of the farmers are female, who carries out farming activities with no accurate agricultural skills, knowledge, finance and infrastructure [121, p. 13]. This results in the loss of not only natural resources but their health as well because of wrong methods of managing soil nutrients and applying fertilizers and chemicals that stipulates further deterioration of the farmlands [23].

J.P. Aryal, T.B Sapkota, R. Khurana., et al. suggest that there are specific sustainability measures that can be taken to tackle climate challenges to prevent washing away the topmost layer of the soil and sustaining the thin freshwater layer by growing vegetation in coastal area as a protective barrier [23]. These measures are potential actions that can be taken to mitigate climatic challenges that jeopardize the Maldivian farming communities [147].

Growing leguminous plants to enrich soil nutrients and diversify crops to reduce plant pathogens transfer could improve resilience to climate change. Actions such as agroforestry and cropping system optimization could be utilized as a means for sustainable land management [117].

The problems of water scarcity, low fertile land, and poor production are not only faced by the less developed countries but also are a huge challenge for developed countries such as the USA and Canada. Sustainable agriculture is one of the most urgently needed works in the USA to tackle air and water pollution, prevent the loss of topsoil and protect biodiversity which are pressing economic issues hindering further progress in the US rural

areas [168], [176]. Thus, the development of sustainable agriculture is a global problem that can be addressed through implementing cutting-edge farming technologies and innovative agricultural methods. Therefore, agriculture needs to become sustainable and resilient, be able to protect the environment and conserve natural resources and benefit the community's economic well-being by increasing yields and helping the farmers have a reliable income for the future [20], [93], [94], [95].

In the Maldives family farmers own less than 0.2 hectares of land, similar to Bangladesh and Vietnam, where this indicator per a rural household amount to 0.24 and 0.32 hectares, respectively [50]. Only 21% of Maldivian farmers entirely depend on their farming activities as a means of living to meet the family's needs, such as health, education, and security. The remaining 79% participate in off-farm activities, being pushed to compensate for the little income they earn from farming and invest their time in construction, fishing, and tourism-related jobs, further exacerbating the situation of low-quality agricultural production.

As shown in Table 1.2, more workers per hectare and smaller farm sizes allow easier supervision, giving a productivity advantage over larger farms.

Table 1.2

Main characteristics of family farms in the Maldives

Farm land (hectares)	Average number of family members	Daily income per person ($)	Share (%) of each type of family farms
0.03–0.05	4	1.6–2.7	25
0.05–0.1	6	1–1.06	50
0.1–0.2	7	1–1.2	15
0.1–0.2	8	1.6–2.4	10

Source: compiled by the author based on [8]

The increase in the number of dependent people in one family reduces the amount of money available for daily needs. For land areas 0.1–0.2 hectares, there are two groups where the family size varies from 7 to 8 members. The farms with more family members

earn a comparatively higher income. This is because the greater a family size is, the more hands to work and manage the fields are there to grow higher yields. It also helps these family farmers produce more for market purposes, increasing their daily income to $2.4 per capita. This amount appears to be the same for the lesser farmlands (0.03–0.05 hectares), where the number of family members is half the number of the family farm with a land area of 0.1–0.2 hectares, increasing the share of income per person.

Table 1.2 also reveals that among small family farms, the most common type is one with 0.05–0.1 hectares of land with six members per family farm. Since the Maldives has very few islands with ample arable land, only 25% of the family farmers have access to 0.1–0.2 hectares. Besides, 25% of the family farms have an area of only 0.03–0.05 hectares. These farmers live on small islands where no land can be allocated for farming purposes so that the locals carry out farming activities in their backyard or inland areas that are allocated for housing purposes. In theory, the family farms with larger land areas must gain a larger share of income per person. However, Table 1.2 shows this is not the case in reality. Though the land area is big enough, farmers cannot reap benefits. This is because highly costly inputs force the farmers to use minimum fertilizers, and they cannot control plant pests and crop diseases due to pesticide inaccessibility. Hence, these farmers can only produce the bare minimum, the same as those with small land areas.

Agricultural land productivity is greatly determined by water accessibility. In this regard, irrigation plays a significant role in increasing productivity. Statistics show that only 1% of the family farmers utilize irrigation systems, and only 5% have access to running water and electricity. This leads to poor growth and economic performance of these farming communities. Farmers use ground-dug wells and petrol pumps to collect water for watering their crops. Farmers use manual watering cans and manual methods in digging and drenching the field, where most of the farmers' time is spent on unproductive activities. Besides, 86% of the family farmer communities do not use automatic machinery. However, a study on Asian family farming shows that irrigation and automatic machinery can double high-quality produce and shrink crop failure.

A similar study carried on understanding the challenges faced by the small family farming communities of Ukraine shows that though lands are available farmers are faced with constraints such as access to quality seeds, agricultural inputs, credits and the aging farming population which are common characteristics observed among Maldivian family farmers as well. At the same time, R. Bezus and O. Samofal highlight the importance of these small family farmers in attaining sustainability in terms of food security, employment and environmental stability in Ukraine [37].

By and large, the fact that the Maldivian family farming communities face challenges such as resource scarcity, climatic issues, poor productivity, and low incomes urges us to introduce small farmers to holistic economic, social, and environmental sustainability. The theoretical essence of family farming and the sustainability category as an object of management gives rise to the concept of "sustainable family farming" in the Maldivian agriculture.

Hence, this Ph.D. research offers to define "sustainable family farming" as working towards sustaining farmers, resources, and the farming communities by pushing towards more profitable and environmentally friendly agricultural practices and by fitting and replenishing traditional ways of farming with new modern agricultural methods applicable to farming activities which are a primary source of farmers' nutrition and livelihood.

1.2. Contract farming models

Agricultural farms and smallholder farming communities' economic activity depends on the interplay between inputs and outputs. Given the constraints of natural resources, such as land, labor, water, and increased cost of production, farmers need to work towards achieving efficiency and effectiveness in their farming activities [58].

The ratio between the outcome of farming and the utilized resources determines the farm activity efficiency. On the other hand, the effectiveness of farming is its ability to fulfill its production targets, goals, and objectives. In other words, indicators of the farm

activities' effectiveness identify how successful farms are in achieving their intended outcomes [13]. Efficiency and effectiveness in agricultural economics and management depend on theoretical frameworks and concepts of production theory, technical, economic, and resource efficiency.

The efficiency of farming activity depends on the farms' ability to maximize their production by optimizing the use of available resources with the minimal cost of production [27]. Consumer preferences, standards, and markets are changing along with time as farms are taking measures and adapting activities to environmental stimuli to produce quality products and services which are different and better off than other farms. Similarly, farms need to manage scarce resources; in a way, the maximum amount of production is adjusted to the external environment.

In this regard, the effectiveness of the farm is its ability to interchange its farming activities with the available resources to produce quality products and services. In a nutshell, efficiency is the standardization of available resources, whereas effectiveness is the differentiation and development of quality products and services [65].

A theoretical framework of farm efficiency in microeconomics encompasses production and technical efficiency. Production means using inputs to produce outputs, where its function represents technological efficiency. Production is the maximum work level a firm can do by combining its available inputs [27]. On the other hand, relative technical efficiency is the performance of an individual producer compared to another efficient producer in the industry. Absolute technical efficiency is measured based on a unique producer's performance compared to the industry's most efficient producer.

A firm is economically (overall) efficient if it achieves technical and allocative efficiency [91]. Technical efficiency shows farmers' ability to produce the maximum output using the current level of inputs. Allocative efficiency is based on the ratio of optimal costs to the costs incurred at the technically efficient level. There the cost is optimal when inputs would be used up to the point where their marginal products equal their prices or opportunity costs [65].

On the other hand, allocative five efficiency measures determine the ability of farmers to use information in an optimal proportion, given the price of inputs and outputs [65]. These five measures include education and awareness of the farmers, quality of agricultural consulting services farmers receive, farming experience, the size of household, and access to agricultural inputs. These measures help the farmers allocate their available resources to minimize the cost and generate more benefits. Farmers with strong knowledge and skills know how to allocate their resources that will minimize the cost and maximize production. Moreover, farmers' experience allows to distribute labor, land, and resources in a way that increases harvests of optimal crops and generates more benefits. The allocative efficiency measures are also greatly impacted by the economic environment. This includes prices of production factors and outputs, the margin between farm gate and market prices, the off-farm opportunities, and access to funding [65].

Economic efficiency is the quality of economic activities to utilize miscellaneous farming inputs such as land, labor, and other natural resources to grow maximum produce to benefit the farmers. To achieve this economic efficiency, they must implement farming strategies that provide benefits more than the cost. Hence, to ensure that farming activities attain economic efficiency, farmers should not implement strategies which don't lead to earning incomes. In contrast, resource efficiency uses the available resource to generate the maximum benefit for the farmer compared to activities without exploiting these resources. That is allocating the available resources to maximize farming productivity and profitability [65].

Some factors contribute to the producers' efficiency. Recent studies confirm that technical efficiency is greatly determined by the level of farmers' education and the extension services provided to the farmers. Producers can improve farming operations through education and consulting, indirectly offsetting farm income in bad production years, ensure the proper use of farm inputs, maintain control over plant pests and crop diseases, and enhance farm management [65].

The smallholder farming communities in the Maldives are trapped in a vicious cycle of high input costs, unavailability of land resources, fluctuating climatic conditions, government policies that hinder them from owning farmlands, a high share of the aged population, and poor extension services. Geographically dispersed islands make it impossible for smallholder farmers to reach market points. In addition, the farming technologies are too expensive for the smallholder farming communities to adopt, which further marginalizes them in increasing their harvests and quality. All these challenges impoverish local farmers, affect their agricultural efficiency, and lead to the country's high dependency on food imports [13].

The research study proves that small-scale farmers benefit from their activities when involved in contract farming. Over the years, it has been grounded that contract farming is a promising solution to improve the effectiveness of family farming. Contract farming directly links farmers and agribusiness to reduce transaction costs. The stable market helps farmers plan and invest their inputs accordingly. This allows farmers to overcome market uncertainties and mitigate risks associated with price volatility, increasing farming efficiency [63].

Contract farming is an agreement with specific obligations binding the farmers and buyers as business partners. This includes agreed terms such as farmers providing a fixed quantity of specified quality products where the buyer agrees to trade their products for the set price [68]. This settlement has become a significant and expanding agricultural practice to organize both large-scale and small-scale production, when there is market liberation [149], [162]. This contract farming helps small-scale farmers move away from subsistence farming towards commercial-level farming where the processor is assured smooth, fixed, quality products rather than relying on the export market [181]. Table 1.3 shows that contract farming is a win-win strategy since both parties gain advantages in the forms of monetary benefits and non-monetary incentives.

Table 1.3

Advantages of contract farming

Advantage	Farmers	Buyers
Monetary benefits	• stable income • reduced losses • cut input costs due to the bulk procurement process • reduced credit risk as the farmer has a binding contract with the company as collateral • improved access to financial support for standard compliance to satisfy market requirements	• reduced cost of production with desired quality and quantity • cut transaction costs for coordination via agreed arrangements for regular and stable supplies, and also procurement owing to scale economies and higher productivity • reduced post-harvest losses due to more efficient post-harvest transport and logistics • diminished investment risk thanks to more efficient utilization of installed capacities
Non-monetary benefits	• guaranteed market • access to extension services and technical support • helps in planning and managing their resources efficiently to reach the pre-defined target production volume and quality • helps farmers, regardless of size, to benefit from the spillover of technologies and skills • improves the living condition of the farming communities both socially and economically	• sustainable supply of required volumes and qualities at required delivery dates • solution for buyers' problems in access to land and labor • reduced supply risks compared to spot market procurement • reduced disease/weather-induced supply risks through geographical diversification • reduced marketing risk due to better alignment of supplies and customer requirements • more consistent supplies through better control over production processes and quality • more flexible response to growing/depressing markets thanks to fewer fixed assets • improved reputation and public relations owing to the inclusiveness of the contract farming business model

Source: compiled by the author based on [113]

M.F. Bellamare puts family farming as a contract based on the production of the agricultural commodity, which binds two parties by an economic relationship that includes the processor and the farmer as the grower. Through this contractual basis, the growers get the opportunity to develop themselves towards industrial farming while benefiting the processor through continuous supply of the agricultural production with required quality and quantity [31].

Similarly, M.F. Bellamare and R.J. Bloem stated that this relationship helps both the processor and the farmer, and hence contract farming is a potential tool for developing the agricultural sector and improving welfare in rural communities [32].

Different types of organizational structures under the contract farming model depend on the needs of producers and processors. In other words, how the contract farming model is formulated relies on the type of products, the company's resources, and the social, physical, and environmental factors surrounding the producers and processors.

There are five different types of contract farming models. As described below, they differ in organizational structure. Though all the contract terms in farming models are standard, some differences exist among embedded services, interest rates, contract procedures, out-grower schemes, business development services, and spot markets. Embedded services include input supply, technical support, etc., provided by the processor as an integral part of the business transaction where the amount of its services is deducted from the farmer's payment. When signing a contractual agreement in farming, the prices of the processor's services to the producer are not specified in the contracts to avoid discussions or are not charged if intended to incentivize farmers [113]. According to the Donor Committee of Enterprise Development, contract farming improves business performance, market access, and ability to compete in agriculture. To achieve these, contract farming arrangements, designed for promising benefits to both the producer and the contractor, are known as different types of contract farming (CF) business models [181]. The way these different models are organized and structured between the buyer and producer, as shown in Table 1.4, means that each model has its distinctive features. There

are five different classes of contract farming models which assist the farmers in producing higher quality yields and earning incomes to sustain their well-being and life.

Table 1.4

Types and characteristics of contract farming (CF) models

Type	Characteristics
Centralized CF model	The buyers strictly control and monitor from sowing to harvesting. Guarantees a fixed quantity and quality of production.
Nucleus CF model	The buyer tracks centralized production and processing by owning the farmers' land. Farmers act as means of labor for technical assistance, extension service, inputs, close monitoring, and supervision.
Multipartite CF model	Different parties provide technical support, inputs, and management of agricultural functions. Guarantees a higher price for farmers' produce and opens them to the new export market.
Intermediary CF model	Forms contractual agreements with the farmers through intermediaries such as lead farmers, farmer groups, or buying agents. Limited support in terms of extension service provided to the farmers. Maintains access to the market through an intermediary with the required support and services. This ensures that the farmers earn an income from their production.
Informal CF model	Entrepreneurs or small companies form very informal contracts with the farmers. The contract is formed on a seasonal production basis where the crops require minimal processing. Minimal inputs, such as seeds and fertilizers, are provided. Limited support in terms of extension service provided to the farmers.

Source: compiled by the author based on [68], [162]

All the contract farming models help the farmers to increase their production and equip them with the latest farming technologies for enhancing the quality of their output. These models serve as a means of mitigating market imperfections [30]. Under this contract, farmers can change the physical input and output markets and get required rural finance and advisory services concerning knowledge, skills, and technologies [184]. The success of all these models depends on how well the partner company/buyer interacts with the farmers and how well they are supported to meet the desired end goal.

Unarguably these models help smallholder farming communities achieve sustainability. It ensures stable incomes by providing market accessibility. Extension services and new technologies are implemented to revamp their farming methods moving towards climate-smart agriculture [179], [188]. It equips farmers with tools to produce quality products and tackle market risks. This way farmers' efforts and investments will not go in vain and thus, it gives hope to the smallholder farming communities. These CF models improve the livelihood of rural population and help the smallholders compete in the market at the same level as large commercial agricultural farms [143].

Indeed, A. Ruml, C. Ragasa, and M. Qaim concluded that contract farming positively impacts the social and economic well-being of farming societies regardless of the type of contractual relationship. The study showed that farmers with marketing and resource-providing contracts have gained higher household incomes. These contractual agreements supported access to credits, inputs, and technologies, which boosted farmers' yields and profits [143].

K. Otsuka, Y. Nakano, and K. Takahashi also showed that contract farming in developing and developed nations benefit small-scale farmers by helping increase their production efficiency and profitability. Authors argued that contractual agreements not only rise farms' incomes but also have positive effect on the quality and quantity of their produce and thus acting as a means of addressing the poverty issue in the developing nations [127].

There are numerous examples of how countries neighboring with the Maldives implement different types of CF models listed in Table 1.4.

PepsiCo (formerly Pepsi Foods Ltd.) launched its business in the Indian Hoshiarpur district of Punjab. It scaled up the exports of value-added processed food by supporting tomato farmers with world-class tomato processing plants and packing. They also support the tomato farmers in production by providing quality tomato seeds, fertilizers, technical support from agronomists, and regular monitoring of crops by their technical team. This is a successful example of the Centralized CF model [66]. In addition, PepsiCo further empowered potato farmers in growing quality potatoes in some districts of India, ensuring a solid market and guaranteed profit for their produce. The Punjab farmers currently produce 650 tons of potatoes per day employing 400 contract farmers, and the company set to provide adequate storage during off-season [57].

The Centralized CF model was also implemented by the Zimbabwe Cottco-Cotton company. The company established a contractual agreement with 77000 smallholder farmers. It provided them with seeds, fertilizers, chemicals, technical advice, extension services, and close monitoring from sowing to harvest [113]. This CF model empowered the farmers to work and produce higher quality products as the number of inputs they receive on credit is based on how well they perform in each harvesting cycle. The Cottco-Cotton company further strengthened this business model by agreeing to incentive the highest quality cotton by offering additional payment and cash bonuses. This prevented side selling and boosted yield and production quality, benefiting both parties [113].

An Indonesian estate, along with the support of the World Bank, spurred the economic development of rural oil palm farmers by establishing state-owned oil palm plantations where farmers were given land and technical assistance in cultivating perennial crops. The Indonesian palm oil boom resulted from the Nucleus CF model that the Indonesian government initiated. Later the government handed over it to the private companies by giving them land areas and subsided loans in exchange for recruiting smallholder farmers into their plantation plan. Through these private companies' farmers

were given support and guidance in cultivating, enabling them to increase their plantation efficiency via higher yields and incomes [123].

The Kampot pepper production contract farming model is the Multipartite CF model implemented among the farmers of Cambodia. In this CF model, farmers sign contracts with cooperatives and private companies to distribute pepper locally and internationally [162]. The Kampot farmers are trained in a continuous manner to equip them with skills and knowledge, and their farming methods and techniques are strictly monitored and regulated based on the specifications of the required product. In return, farmers are guaranteed a higher price for their produce, opening them to new export markets. It showed that the Kampot farmers earned a higher income than the non-Kampot ones, increasing their average annual revenue from $400 per household in 2009 to $1750 per household in 2015 [162].

The snap-frozen vegetable industry in Northern Thailand contracts with collectors who coordinates more than 30000 farmers who grow different varieties of beans. The company provides the subcontract farmers with technical expertise and extension services through these collectors. This Intermediary CF allows access to the market through an intermediary with the necessary support and assistance [151].

The Informal CF model was implemented by Green Agro Park Ltd., an Indian company in Karnataka that directly states that it deals with 3500 small farmers to produce Gherkin, and nearly 1400 acres are under the cultivation of this crop. To some extent, the company provides minimal support, including input and technical assistance. Farmers' production has no local market, so they must depend on the company that assures a 100% buying guarantee for their produce. However, the company rejected most of the products due to poor quality caused by plant pests and crop diseases, against which farmers did not receive sufficient support [151], [156].

Besides, contract farming is good at addressing malnutrition and food insecurity. In particular, M.F. Bellemare and L. Novak researched the impact of contract farming on

struggling poverty of the Madagascar rural population. There is unequal access to food among males and females in rural communities where female children show a prevalence of stunted growth and nutrient deficiencies. The study showed that owing to contract farming the rural population improved its access to food during the harvesting seasons and gained enough incomes to buy food afterwards [33].

R.G. Grafton, C. Daugbjerg, and M.E. Qureshi put forth similar arguments regarding farming and food and nutrition security. They predict that by 2050 the global agriculture must be able to feed 9 billion people sustainably. Along with increased food production, food must be accessible and reachable to the needed population [70]. For this to happen, contract farming should facilitate access to agricultural inputs and markets when trading agricultural commodities.

Similarly, a research study by N. Vasylieva on food security and dynamics of populations argues that accessibility and affordability of food products is the primary socio-economic mission of every state. Like urbanization, the outbreak of COVID-19 was a wake-up call for many nations to strengthen family farming communities and ensure availability of healthy diets. As per the author, food sustainability must be maintained by addressing the limitations of cultivated croplands, supporting smallholder farmers in reductions in post-harvest losses, and enhancing production and trade opportunities [171], [172].

Given the benefits of contract farming in developing food security and sustainable agriculture, the Maldives also strives to go the same way. At the Maldives Partnership Forum, the newly elected government of the Maldives outlined a national strategic plan to increase the self-sufficiency and food security [100] as part of the national strategic “Blue Economy”. Under this initiative the government has established a 100% state owned company named as named Agro National Corporation (AgroNAT) to support farming communities in enhancing the production capacity of the farmers to fulfill a reduction in imports of agricultural crops [14].

The government budget administers AgroNAT, where donor agencies support the cooperation financially and technically in achieving its goals [14]. AgroNAT implements the contract farming business model as one component of the company in empowering and sustaining family farmers by facilitating access to farm inputs and providing markets for their production. In addition to this, it also supports farmers in acquiring credit schemes from banks and provides technical help in starting up farm businesses under the CF model [2].

The main objectives of the AgroNAT contract farming include the following:

- expand agriculture in the Maldives;
- establish mechanisms to ensure sales of agricultural produce from local farmers;
- achieve food security as an economic goal;
- reduce dependency on food imports;
- increase employment and income-generating opportunities for farms;
- revamp agriculture with technology.

The AgroNAT corporation implemented the Centralized CF model to achieve these objectives. Contract farming is a new concept in the country's agricultural sector, which requires many awareness programs and recruiting work to onboard rural communities and small family farmers [2]. The outlined Centralized CF model (see Fig. 1.1) implemented in the Maldives in 2020 leads to achieving the farmer's desired outcomes and goals initiated by the AgroNAT corporation. Along with the above objectives, the company's core values worked toward empowering rural female farmers to attain financial independence, stability, and efficiency in the locally produced agricultural products supply chain. It also equips farmers with advanced agricultural technology and innovations in removing from traditional, outdated farm methods. The most important value of the contract farming model is facilitating the locally produced goods to be sold at the local market.

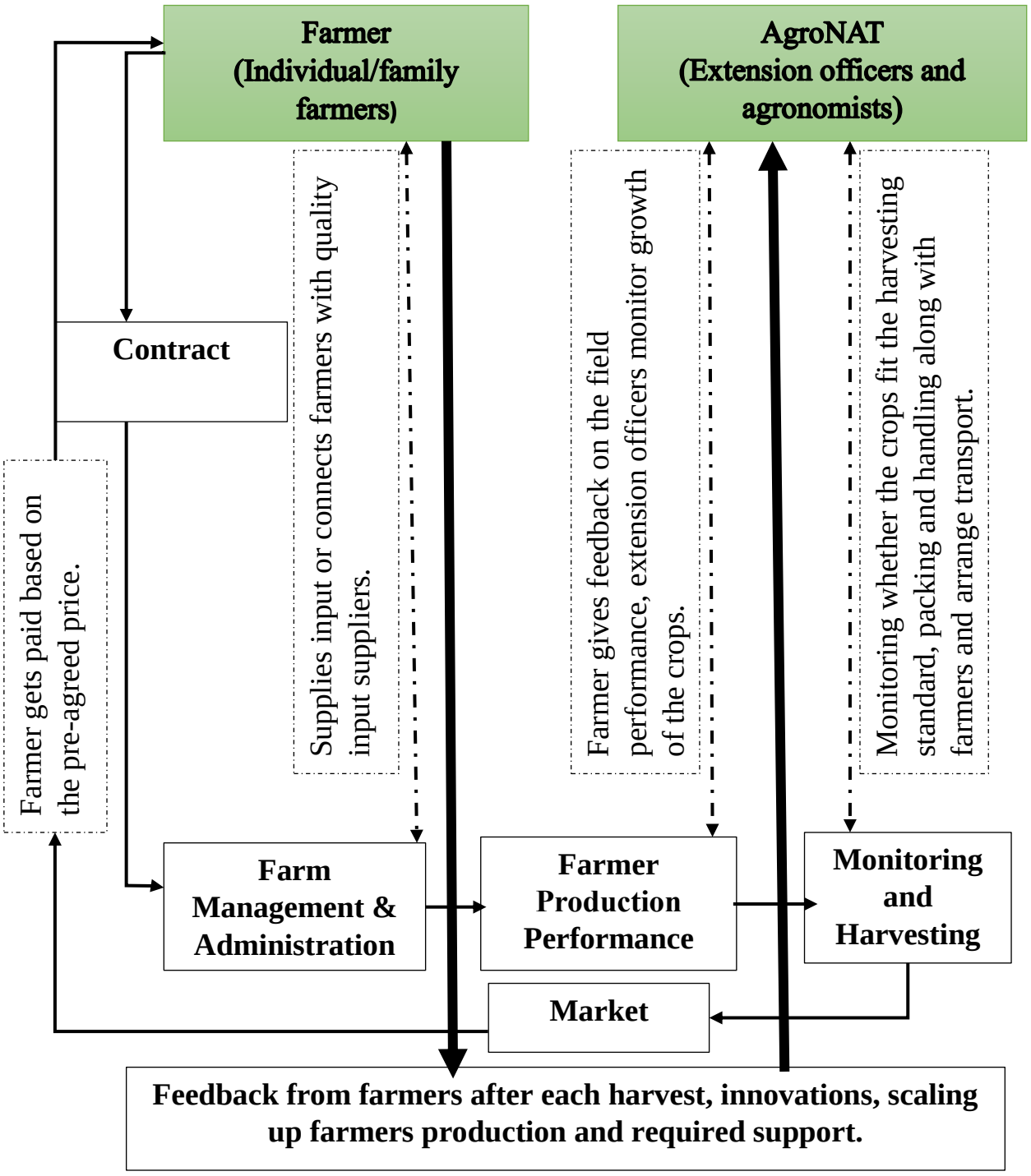


Fig. 1.1. AgroNAT Centralized CF model

Source: compiled by the author based on [2]

Successful implementation of the CF model in the Maldives implies effective and efficient family farming. Namely, small farmers who cooperate with AgroNAT provide effectiveness through growing maximum possible harvests of the chosen crops. In contrast, AgroNAT is mostly responsible for agricultural efficiency as it supplies inputs, transmits cutting-edge technologies, ensures credits and loans, and supports produce sales of the contract family farmers. However, the current practical results are far from the expected ones. That is why, the Ph.D. research will analyze, study, and explain how the management of contract farming helps achieve its goal and how the CF model could be further improved to provide agricultural sustainability of the Maldivian farming communities.

Within the Centralized CF farming model, the AgroNAT corporation signs a binding agreement with the farmers if they have more than 2000 sq. ft of farmland leased for at least a two-year period. After signing the contract, farmers can select two crops (short-term and long-term ones). Short-term (or annual) crops take a comparatively short period from sowing to harvesting. This includes cucumbers, butternuts, pumpkin, melon, sponge gourd, and snake gourd. Long-term (or perennial) crops (like bananas and papayas) take more than six months from the time of sowing to the harvesting stage. In addition, farmers need to consider the distance from their farming land to the main market points as there is no cold storage available, and transport takes up to 3 days for some islands to transport their produce to the potential buyers [14].

Once farmers choose their crops, they are given a list of items, including fertilizers, pesticides, fungicides, tools, and equipment required for farming, with prices and amounts for the farmer-specific land size and crops. Farmers can pick out equipment and tools based on what they have or not. However, farmers must choose all the fertilizers required to grow the crop [7].

The starter pack is given based on the crops farmers opt for growing and their land size. This starter pack is given on a credit basis, where the farmer can pay it upfront or

after harvesting and then leave items from this starter pack. The selected items are delivered to the farmers, who do not have to pay for transport [14].

Extension officers who work with the farmers of each island take strict control measures to maintain the standard quality of the crop.

Quarterly farmers are trained, and farmers' feedback is taken to improve the quality and sustain produce uniformity. To sum up, under contract farming, AgroNAT provides farmers' support in the following three areas:

- market provision, meaning that AgroNAT buys the products of all the contract farmers and provides sales and purchases of the crops;
- resource provision, supposing that in conjunction with the marketing arrangements, the company also supplies selected inputs (starter pack by the farmer selected crop), including, occasionally, land preparation, propagation, as well as expert advice and support in dealing with different plant pests and crop diseases;
- management specifications, meaning that the company recommends production methods, input regimes, and cultivation and harvesting specifications.

Each contract farmer is given a starter pack based on their selected crop type. This starter pack includes tools, equipment, seeds, fertilizers, and pesticides/insecticides required to grow and harvest respective crops. The purpose of the starter pack is to reduce the cost factor/recurrent cost (input cost), forcing farmers to produce quality products with a lower unit cost to accelerate the contract farming by providing initial agricultural requirements [7].

Given that most of the farmers are family farmers, due to the burden of house chores, they cannot start farming as per the schedule, and they are given leniency to start within an additional one or two months. In some cases, unforeseen weather conditions such as high waves, prolonged dry conditions, or heavy rain wash away all the applied fertilizers, leaving farmers without any yield. Farmers are given additional free input for the cultivation cycle in such cases. There is no established procedure or policy to address

such concerns of farmers. In other words, there are no farmer insurance policies. However, AgroNAT supports contract farmers in recovering such losses by delaying their credit payments until they harvest in the next cycle.

The company also provides farmers with cost analysis of their farming activities and helps them keep track of their farm investments. Before starting each cultivation, they are given their capital cost, recurrent cost, and how much they will yield at the end of each harvest. Based on this, farmers can understand the profit they will gain at the end of each harvest. In addition, farmers get packing materials, weighing scales and are guided in harvesting and handling the crops [2].

Given that the contract farming model is the first initiative taken by the Maldives government to strengthen the family farming communities of the Maldives, it lacks institutional-level policies, strategies, and capacities to address all the challenges and issues faced by the farmers. One of the company's objectives is to strengthen the farming communities regarding farm income as the company pays for all the product's set prices after categorizing the produce based on its quality. Though the farmers cannot send their produce to the nearest market point due to bad weather and transport difficulties and go to damage, the company pays for their harvests once it's been harvested and weighed by the responsible extension officers based in that farming communities [14].

The AgroNAT corporation takes the above measures to alleviate the farming population's poor economic and social status. This is a priority because the Maldives is a country highly dependent on food imports. At the same time, rural residents depend on subsistence farming to meet their daily requirements. In some cases, these family farms build the livelihood of that specific island community. Therefore, further development of resilient, strong family farming in the Maldives urges to look into how contract farming management can be improved to push the small family farmers toward economic, social, and environmental sustainability [14].

1.3. Farm management in development of sustainable agriculture

"Farm management" term itself encompasses two words that are "farm" and "management." A farm is considered a piece of land where productive resources are transformed into outputs under control of a head person who acts as a manager of an economic unit. In other words, a farm is a land where crops and livestock are transferred to outputs by common management with certain boundaries [13].

A farm is a socio-economic unit where the decisions are made collectively by the unit, where the farmer has many alternatives for his resources in producing crops and livestock and their disposal. The income achieved via farming activities is a source of livelihood and prosperity for a family unit [69].

Management is a process where a group of individuals work together towards a common goal and takes measures to accomplish the selected aims. It is a process that encompasses planning, organizing, and coordinating the personnel, resources, and materials to achieve the common goals of the individual groups [13], [73]. Management is a concept applied to various fields depending on organizational characteristics and function [124].

Farm management is a branch of agricultural economics that explores how to allocate agricultural production factors such as land, labor, and capital to fulfill farm potential and enhance outputs [13], [74].

According to [62, p. 11, 12], A. Boss, H.C. Taylor, and L.C. Gray define farm management as "the process of organizing the operations of daily farm activities to gain economic benefits, effectiveness and efficiency measured by the net profit from farming". Similarly it also states that according to G.F. Warner and J.N. Effersen, "farm management is all about planning, organizing, and implementing strategies that allow farm resources to ensure a profit in a continuous manner" [62, p. 11, 12]. Farm management researchers L.A. Bradford and G.L. Johnson determine farm management as a way for the individual farmer to organize and align his assets and resources and how it

is being spent to ensure that operations of the farm activities generate the maximum possible net income [43]. Meanwhile, R. Kay, W. Edwards, and P. Duffy state that farm management is about decision-making in allocating limited production resources for organizing and operating a farm unit as a business to generate maximum revenue and reach its goals [85].

All these definitions by different authors agree to have common aspects, which include a process and way of managing farm resources and inputs to reach the financial aims. Hence, farm management embraces the whole management process including planning, organizing, implementing, monitoring, and controlling the farm resources to provide the desired outcomes. Thus, successful farm management generates maximum profit with the available farm resources to sustain the farming communities [42], [162].

Farm management is a field of microeconomics, where management is intended for allocating, implementing, and tracking the limited resources of a farm unit. The whole purpose of farm management is to support advantageous farming. According to R. Kay, W. Edwards, and P. Duffy, farm management is about making managerial decisions that combine the input and output to boost farming activities by incorporating economic principles, dealing with risks, and mitigating production uncertainty [85]. Similarly, G. Stephenson states that farm management implements cost-effective strategies and strategic plans to acquire equipment, establish infrastructure, manage day-to-day operations, and select a business structure that incorporates the sustainability dimension for long-term viability [154].

As a subject matter, farm management involves the application of business principles in farming activities where the tools and techniques depend on economic theory relevant to agriculture [74]. This includes some major economic principles which help in rational farm management [52].

The law of variable proportions or diminishing returns explains how the farm’s available resources can be organized and aligned to produce maximum output. The cost

principle looks into how farm activities can be organized to minimize a loss and informs how resources can be combined to produce a maximum output with a minimal cost.

The principle of factor substitution helps the farmer as a manager to decide how to increase outputs through allocating available resources. The principle of product substitution guides managers in deciding what to produce for the optimum production [52], [126].

The principle of equal-marginal returns helps farm managers to distribute and utilize the limited and scarce farm resources for optimal production. The time comparison and principle of comparative advantage is about regional specialization in manufacturing commodities and supports the managers in making efficient investment decisions to amplify the efficiency and effectiveness of available resources utilized for profitable production [13].

All these economic principles of farm management envelop the key farm management functions. They are about making decisions that affect the ability of the farm to gain a net profit which involves formulating plans, executing those plans under strict control and monitoring measures to achieve the farm's objectives. Meanwhile, they inform what tools and techniques are necessary, what technology must be integrated, and what tracking approaches should be implemented to ensure that the farm uses its available resource most effectively and efficiently to optimize its production [5], [52].

One of the core factors of farm management is decision-making. When it comes to family farming, it plays a huge role in the continuity and economic viability of the rural communities, as the environment around them greatly impacts farming. This comprises numerous factors like agricultural inputs and product prices, technological advancements, unpredictable weather conditions, government policies about farm practices, input subsidies, and farmers' awareness and capacity [5], [144].

Regardless of these factors, farm management is based on an economic method designed to assist the most cost-effective decisions with a maximum return. Being the most useful of all, the economic method of farm management ensures the viability and

continuity of farming activities [55]. This stems from the core functions of farm management such as planning, organizing, implementing, and controlling farm activities.

Firstly, farm management plans out the farm objectives that are realistic to achieve concerning the labor force, climatic and topographic features, and demographic trends. It then lays out approaches to achieving these goals and identifies the farm resources and alternative methods to fulfill the set targets and aims [42], [74]. Secondly, after planning, the farm unit must be organized so that the planned farm activities can be executed to attain maximum production efficiency employing available human, natural, technical and financial resources. Thirdly, when the farm fulfills its plans, farm management coordinates and supervises land, labor force, and capital to achieve target goals. Finally, by controlling farm management observes and monitors the implemented plans, strategies and their accuracy to the set purposes. Farm decisions, changes, and adjustments are to be made through decision-making in relation to daily activities to ensure that the farm goals and objectives are in focus [84].

In other words, the functions of farm management, regardless of whether the farm is a small household or big entrepreneurial economy, include organizing its resources to form an economic unit, putting in practice the most cost-efficient method to produce the maximum amount of crop, manage the farm capital, redistribute its budget to maintain that investments are allocated rationally. Thus, in both cases, farm management is invaluable. This is because farm management suggests how to raise the yields and profit margin of the farm despite scarce resources and limited production capacity [72].

The succession or continuity of the family farms and the success of their business performance depend on farm management. Family farms play a vital role in the survival of farming communities, passing the landscape and soil fertility to the next generations and providing employment and food security. Family farming is a way of life that directly contributes to the sustainable development of the whole agricultural system [160].

Authors who study family farming management emphasize the importance of agricultural knowledge and skills in performing farm activities for the viability of rural

communities. According to J.S. Reyes and E. Fuetsch, the continuity of the family farms cannot be sustained depending on the farm's adaptability to change along with the environment but instead it can stem from the farmers' capacity and intention to successfully carry the family's heritage into the future [139]. However, there are many challenges faced by the family farming communities to continue as successful businesses. Hence, it is essential to maintain the functional ability of the family farms at the local and national levels.

The whole agricultural system thrives on effective and efficient family farming, so supporting policies of enhancing farm management need to cover the following basic dimensions [139]. Firstly, regarding political and ecological aspects, it is about

- subsidized interest rates on loans;
- credit guarantees;
- infrastructure developments to help boost direct farm sales;
- allocating funds to continue farming;
- reviewing food safety provisions to shrink red tape;
- encouraging climate change adaptation and mitigation;
- fostering family farmers in developing rural agro-tourism to sustain the cultural and environmental landscapes.

Secondly, the social dimension is focused on closing the gender gap, which means

- to reform policies and regulations on rural land tenure to benefit women and vulnerable groups;
- to elevate females from the secondary role and make their work in the rural economy more visible;
- to develop policies that facilitate female access to education and credits.

Thirdly, encouraging innovations and competitiveness suggests

- effective transfer of farm ownership and management responsibilities from one generation to the next one;

- facilitating greater access to land for young people looking to enter farming for the first time;
- training farmers with knowledge and skills to adapt modern technologies to produce high-quality food;
- increase farm profitability to reduce the number of businesses participating in the supply chain between the farmer and the final customer;
- support family farmers to be involved in short supply chains and to better integrate family farms into distribution channels by assisting quality schemes, adding value to agricultural products, and their promotion;
- maximize the utilization of a farm's assets for better production, effectiveness, efficiency, and profitability.

Unfortunately, the Maldivian contract farming model failed to attain its objectives successfully. Reports show that AgroNAT is running below breakeven with a negative cash flow and profitability. Hence, it emphasizes the importance of improving management of contract farming to achieve sustainability of rural communities as a part of the Maldivian agriculture.

It is management consulting that can help the company identify changes and improvements for allocating resources and optimizing farm activities to cover the capacity gaps that hinder organizational performance. Thus, management consulting is a workable tool to help AgroNAT reach breakeven with a positive cash flow and profitability [5].

In general, management consulting generates the desired result by implementing successful strategies and concepts of an organization, either supporting or guiding it to formulate and fulfill new goals. Management consulting helps the company develop a strategic plan for acquiring equipment, executing day-to-day operations, and selecting a business structure for long-term viability, where it emphasizes sustainable agricultural practices [5], [8].

Thus, management consulting provides family farmers with expert opinion and guidance on the management of their farming activities to face the challenges of modern society, ways to preserve the ecosystems through restructuring agricultural production as processes of lower impact and using resources in an optimal way with a minimal waste [83]. In other words, management consulting helps maintain the farm's future viability in a changing world by increasing its efficiency and effectiveness in planning, organizing, leading, and controlling human, financial, physical, and informational resources [3].

R.J David, W.D Since, and H.A. Haveman proved that management consulting withstood the test of time and gave a detailed description of how this process occurred through World War I and II, which led to the formation of the legitimate professional form of management consulting. These authors also have stated that in their studies that the first recognized management consulting firm was established by A.D. Little in 1890, when the industrial revolution appeared to be the powerful driver for the emergence of consulting firms [53].

A consultant is usually an expert or a professional in a specific field with a vast knowledge of the subject matter [3]. There are several definitions proposed by different scientists for the concept of management consulting. Indeed, the UK Institute of Management Consultants introduced management consulting as a service provided by an independent and qualified person or people to identify and investigate business problems concerning policy, organization, procedures, and methods, recommend appropriate action, and help with implementing these recommendations [167].

It also considers consulting as a complex professional activity in which the consultant employs technical and problem-solving skills, specialized knowledge, and work systems and processes to improve the function and outcomes of the consultee.

P. Block defined a management consultant as a person who is in a position to influence an individual, group, or organization but needs to possess direct power to implement appropriate changes or interventions [39].

According to M. Alvesson and A.W. Johansson, management consulting is a way of providing honest feedback, where it offers straightforward and objective advice on the appropriate actions for the organization, all without concerns about potential consequences [18].

M. Kubr defines management consulting as “an independent advisory service assisting managers and organizations to achieve organizational purposes and objectives by solving management and business problems, identifying, and seizing new opportunities, enhancing learning, and implementing changes” [88, p. 7]. Among all the definitions, M. Kubr’s definition best fits the basic principles of management consulting about the sustainable development of agricultural enterprises.

According to FAO reports, consulting services play a remarkable role in attaining sustainable development in agriculture. Consulting helps reform and support technology transfer and extension services to meet food and nutrition security challenges, poverty reduction, and environmental sustainability, linking farmers, civil society, government organizations, and the private sector [166].

Through consulting services, technical knowledge is made relevant, and farmers are directly involved in learning cutting-edge technologies and adopting agricultural practices for sustainable development. Furthermore, it helps farm management remain economically viable, providing farmers and food processors livable wages and safe working conditions. By creating good jobs and building strong communities it also bolsters local and regional economies [88], [166].

Governments and companies have already accepted the importance of advanced management consulting. In today’s world, a new concept of sustainability is added to management consulting to meet the global demands and provide tools and expertise to implement sustainable solutions [109].

According to S. Hart and M. Milstein, sustainability means expecting to improve the present generation’s social and environmental performance without compromising the future’s ability and opportunities in this area [72]. Besides, G. Whiteman, B. Walker, and

P. Perego urge businesses to rebuild their management strategies around sustainable development concepts to tackle the social, environmental, and economic challenges [180].

Management consulting is a business consulting that is about implementation of suggestions and services to improve the efficiency and effectiveness of the organizational strategies, work towards the company goals, and realize more growth [180]. Management consulting moves beyond just formulating cost-efficient strategies but also provides expertise to enhance business processes by means of new IT systems, outsourcing non-core tasks, or forming an optimal supply chain [180]. Management consultants are business experts who help the organization break down miscellaneous challenges and problems as well as analyze and provide solutions to them.

A management consultant acts as a teacher, educating and making organizational management aware of its loopholes and helping with understanding innovations. Along with directing the organization toward growth, management consulting helps discover advanced workable methods of the production process in the company. At the same time management consulting determines what alternative solutions can be implemented and identifies the consequences of opting for each solution [180].

Management consultants' years of experience and expertise are essential in managing organizations that want to increase efficiency and effectiveness. The proficient management consultants can offer solutions based on successful business strategies and customize them to fit the client's organization [3]. These specialists consider problems from different perspectives, aiming at minimal production costs and quality outputs. This leads to implementing strategies and policies that allocate production factors such as land, labor, and capital to yield the most significant net return while adhering to sustainability [180].

Management consulting in agriculture is essential to gear up the sector and its management towards 21st-century market demands and consumer needs. It plays a primary role in improving farming efficiency, productivity, and profitability to develop long-term managerial plans which take into account market trends, crop prices,

technological advancement, and environmental factors. Moreover, consulting helps farm management to make informed decisions on what crop they should grow more and what market they must produce for that best fits the farm activities. This way farms are encouraged to adopt new technologies and practices, such as precision agriculture, crop monitoring systems, efficient irrigation methods, as well as agricultural regulations and standards relevant to sustainability [3].

Agricultural extension service (AES) is an innovation from the 20th century designed to develop the agricultural sector by uplifting farmers and supporting farming communities to adopt modern technologies and reduce the burden of the cost of acquiring agricultural knowledge and skills [91]. AES is the key agent in diffusing the knowledge and developments from the agricultural research centers, universities, and agricultural management consultants to the farming communities, including production methods, optimal input use, and management practices. Research studies shows that AES offices are in low- and middle-income countries, notably 70% in Asia [82].

Compared to management consulting, AES fosters the agricultural production of farming communities by educating individual farmers on crucial issues such as cropping methods, fertilizer application, food storage, and farm management [140]. In other words, it improves the farmers' agricultural knowledge, assisting them in increasing crop harvests and the total efficiency of their farming activities [3], [38].

AES officers support farming to improve their knowledge, attitudes, and skills and increase productivity in rural communities [38]. Similarly, P. Isubikalu stated that AES officers are the ones who directly and indirectly conduct training and education programs for improving farming practices, methods, and techniques to boost production efficiency and income generation, provide better living conditions, and lift the social and educational standards in rural areas [82]. The Food and Agriculture Organization of the United Nations defines AES as an informal education promoting the knowledge, attitudes, skills, and aspirations associated with agriculture and rural development [50]. According to W.

Athukoroala, AES officers are strongly allied with agricultural productivity in developing countries and are the key components of the agricultural sector after the farmers [27].

The central role of the AES officers is to develop farmers' knowledge and skills for agricultural accomplishments which depend on the farming goals and objectives. AES officers are the people who work closely with the farmers and understand their circumstances, challenges, and opportunities for adopting new technologies and innovations to enhance their farming activities. In other words, AES officers connect or bridge the agricultural management decisions, strategies, policies, and plans with the farming communities and individual farmers, through education and communication to build the farmers' capacity in terms of skills and knowledge [27].

To carry out their roles and responsibilities, AES officers hold workshops, seminars, and training sessions to inform farmers about modern agricultural techniques, pest and disease management, soil health, and sustainable farming practices. They perform on-farm demonstrations to prove practical benefits and encourage adoption of new technologies [38].

With AES demonstrations, officers show and teach farmers the ways to reduce input costs which is a key aspect when it comes to water usage, fertilizer application, and weeding. In addition, the farmers are guided how these new technologies can be used in their fields and also prepared to evaluate production constraints and understand proper approaches to raise productivity [27]. By training and educating AES officers support the farmers in developing sustainable agriculture and providing food security [27], [64].

AES officers must work closely with the farming communities to assess challenges, suggest personalized recommendations, and offer guidance on specific agricultural issues. Throughout their work, the AES officers collect data from farms and communities to evaluate effectiveness of agricultural programs and make data-driven instructions. They engage local communities in identifying their specific needs and address socio-economic challenges related to agriculture.

All of the above-discussed roles and responsibilities of the AES officers depend on the farm management strategies and policies designed to achieve the targets of farms in their agricultural activities. In other words, the optimal crop, its best production method, the maximum amount of the harvest, and necessary resources are dictated in the strategies and policies designed by the management. AES officers transmit this to the farming communities so that their capacity can be built in the optimal way [38].

Therefore, one of the critical aspects in improving farm management is to engage management consulting to reinforce the capacity of the AES officers who can translate winning managerial strategies and policies to the farm level.

One of the most advanced and structurally organized agricultural extension services is observed in the agriculture of the USA. The US AES is established in a way that it goes beyond just providing information and farmer support. According to the National Institute of Food and Agriculture (NIFA), the US AES is a cooperative endeavor between the US Department of Agriculture (USDA) and land-grant universities (LGU) [48]. In each state LGU are responsible for delivering educational programs and consulting farmers [48].

The AES officer's capacity is built through continuous intervention with the latest agricultural information and technologies so that this knowledge and skills are easily transferred to the farmers. Through these cooperative extension services, AES officers disseminate the latest agricultural research findings by conducting workshops and training sessions to empower farmers with research-based information [177]. The US AES not only provide access to agricultural innovations but also assist American farmers in adapting to climate challenges such as water scarcity, implementing climate-resilient practices, adjusting to shifting consumer preferences, and diversifying crops to meet evolving market demands [71], [168]. According to S.L. Wang, the US AES is the critical force that has led to empowering American agriculture and brought many economic benefits to the whole nation, including a high internal rate of return and productivity growth [177]. J.M. Alston, M.A. Anderson, J.S. James, and P.G. Pardey state that the US AES contributed to enhancing the farmers' production, which accounted for 7.3% per year. One of the main components of American AES is developing competent youths to carry out modern profitable farming activities [17].

The Canadian AES is also a well-established agricultural extension service system typically presenting a collaborative effort involving federal and provincial governments, research institutions, and various agricultural organizations [128]. To improve the AES effectiveness and efficiency, regional and local offices are established to work closely with the farmers. One of the remarkable characteristics of the Canadian AES officers is that they not only disseminate research findings but also are eager to identify challenges faced by the regional farmers through on-farm trials and experiments. AES are conducted through different channels where farmers can access information workshops, field demonstrations, printed materials, websites, and digital platforms to evaluate the effectiveness of new technologies and practices [128].

R. Bezus and M. Dubchak argued that agricultural advisory services present a perspective powerful tool to improve productivity and incomes of smallholders in Ukrainian farming. However, governmental programs promoting cooperation between agricultural advisory services and other consulting institutions are in decline that has a negative effect on rural development and exacerbates living standards of farmers [36].

J. Pretty states that the national AES have been instrumental in enhancing sustainable farming so that they helped reduce the environmental impact on farming communities by integrating sustainable farming methods. It also has facilitated farmers to adopt risk mitigation techniques and technologies, enabling informed decisions, optimizing inputs, reducing the cost of production, and improving farmers' profitability and the well-being of the rural communities [133].

By and large, management consultants in agriculture and AES officers are crucial in supporting farming communities to achieve production efficiency and develop sustainability. Through management consulting, they design and promote production methods that address specific farming challenges and ways of raising harvests, which is in the best interests of the family farmers. In other words, management consultants focus on providing strategic advice to optimize farm businesses, and AES officers work on educating and empowering farmers with the latest agricultural knowledge and cutting-edge practices to achieve the set targets.

As shown in the Fig. 1.2, each and every functional stage of family farming such as planning, organizing and implementing can be strengthened by combining management consulting and agricultural extension services where these activities are closely monitored and guided to ensure that farmers achieve objectives of contractual agreement and move in the right direction. Hence, management consulting and agricultural extension services need to be implemented in parallel to support continuity and viability of farming communities as this fusion is bound to be the basis of robust food security and sustainable agriculture.

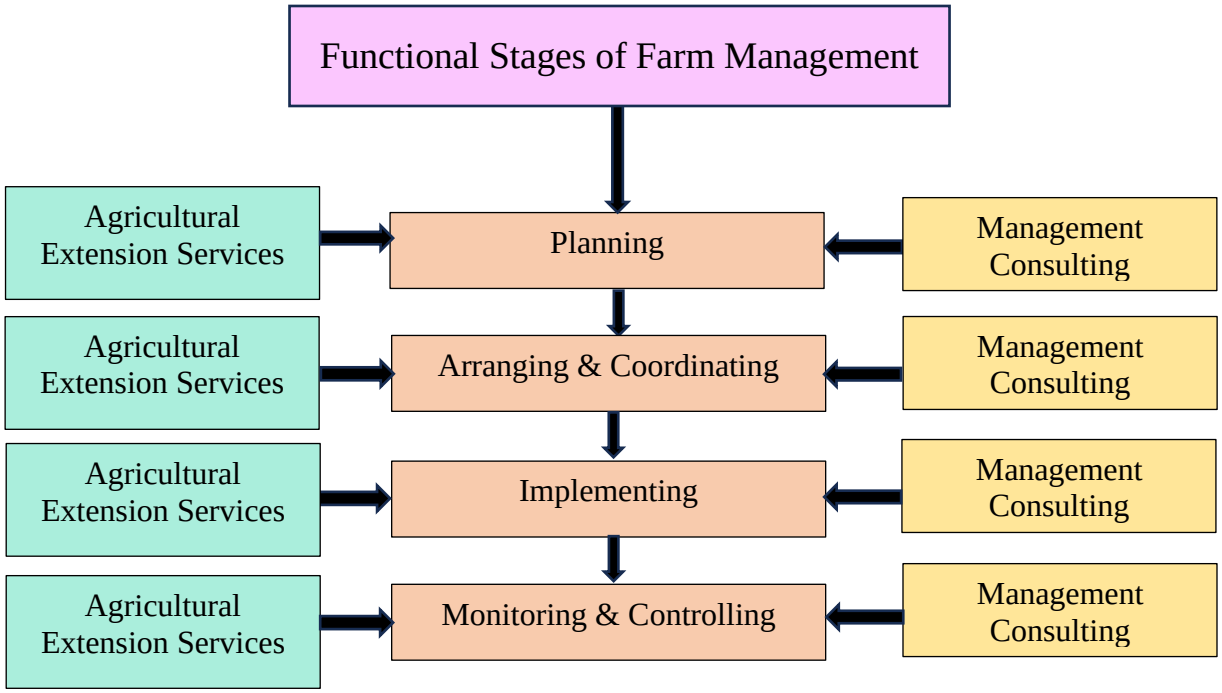


Fig. 1.2. Scheme of farming support

Source: compiled by the author based on [3], [5]

Conclusions to Chapter 1

1. Family farming is a predominant form in the world agriculture. Its whole concept is based on labor force provided by the family members, who own and manage the entire

business where the family itself bears the risks with no legal status. Family farms are in charge of rural development, poverty reduction, and maintaining nutrition security to society. Comparing different economies, such as developing, transitional, and developed nations, it is evident that family farms play a significant role in the agricultural sector, contributing to food production as well as generating employment opportunities and incomes in rural communities. In the Maldives small family farming is performed on less than 2 hectares of land and farming activities are controlled by the head of the family. With inefficient delivery of inputs and insufficient investment, the primary production goal of small family farms in the Maldives is to address own consumption, while only leftovers are used to gain economic benefits.

2. Family farming is a driving force in dealing with the world hunger and malnutrition through promoting sustainable agriculture as part of the United Nations Sustainable Development Goals. Sustainability means improving the present generation's well-being without compromising the future's ability concerning three basic pillars in natural/ the environment/ the planet, social/ society/ people, and economic/ the economy/ profits dimensions. The key challenges faced by the Maldivian family farmers are resource scarcity, including land, water and machinery, climatic issues, poor productivity, outdated farming methods, low revenues and high livelihood vulnerability. This is because 50% of small farmers have to operate on 0.05–0.1 hectares providing 6 family farmers with a daily income of a bit more than $1 per capita which is insufficient to cover basic health and education needs. It gives the rise to the concept of "sustainable family farming" in the Maldivian agriculture on the way to encouraging and implementing environmentally friendly socially-responsible farming conducted by economically viable rural communities.

3. Contract farming is an agreement with specific obligations binding the farmers and buyers as business partners. Farmers are responsible for providing a fixed quantity of specified quality products while the buyers are in charge of trading their products for the set prices. Main types of contract farming models are Centralized, Nucleus, Multipartite,

Intermediary, and Informal which demonstrate promising results in agricultural practice. Being different organizational structures, all these models have similar monetary benefits and non-monetary advantages so that they finance and consult farmers, equip them with the cutting-edge agricultural technologies, help in producing higher quality yields and serve as a means of mitigating market imperfections in order to protect farmers' incomes, ensure their well-being and life sustainability. Simultaneously, buyers gain access to farmlands and labor force, decrease supply risks, reduce harvest losses, improve reputation and public relations owing to the inclusiveness of the implemented contract farming business models.

4. The state Agro National Corporation launched the Centralized contract farming model which aims to expand agriculture in the Maldives, establish mechanisms to ensure sales of produce from local farmers, achieve food security as an economic goal, reduce dependency on food imports, increase employment and earning opportunities for smallholder rural communities and revamp local agriculture with advanced technologies. With contract farming, AgroNAT provides farmers' support in the areas of market provision, resource procurements and consulting, meaning that the company recommends production methods, input regimes, as well as cultivation and harvesting specifications. Contract farming model is a promising solution intended for elevating effectiveness and efficiency in the Maldivian agriculture. Namely, small farmers who cooperate with AgroNAT are supposed to increase effectiveness through growing beneficial crops, whereas AgroNAT is in charge of agricultural efficiency as it supplies inputs, transmits advanced technologies, ensures credits and loans, and supports produce sales of the contract family farmers.

5. Farm management is a branch of agricultural economics intended for arranging daily farm activities to gain economic benefits and fulfill farm goals by means of allocating limited production factors such as land, labor, and capital. Farm management is about decision-making to maintain farming effectiveness and efficiency in the context of sustainable agriculture which implies developing national food security as well as

providing incomes and prosperity for rural communities. Farm management is a process that encompasses planning, organizing, coordinating, monitoring and controlling the personnel, resources, and materials to ensure a profit and quality output in a continuous manner, encourage innovations and foster long-term competitiveness. The succession of the family farms and success of their business performance depend on improved farm management concerning specific economic, social and ecological challenges observed in the contract farming model in the Maldives.

6. Management consulting is a workable tool which helps with developing strategic plans and executing day-to-day operations through allocating resources and optimizing farm activities to cover the capacity gaps that hinder to achieve farmers' goals. Management consulting is provided by independent competent specialists who are qualified in the field of expertise, can maintain an unbiased assessment and are able to recommend problem-solving methods to seize new opportunities and how to implement the generated suggestions into farming activities to realize more growth. Management consulting will provide higher efficiency and effectiveness of farming if combined with agricultural extension services which ensure complex professional customized support of family farms in managing land, labor and capital to harvest more crops while adhering to sustainability. The AES officers skilled in management consulting will be ready to address economic, social, and environmental challenges relevant to Maldivian agriculture from different prospects, teaching and empowering farmers how to utilize cutting-edge farming methods and result-oriented technologies to develop food security in rural areas and at the national level.

The scientific results of Chapter 1 are published by the author in [2], [3], [5], [7], [8].

CHAPTER 2.
STATE OF FAMILY FARMS' DEVELOPMENT THROUGH CONTRACT FARMING IN THE MALDIVES

2.1. A statistical profile of agriculture in the Maldives

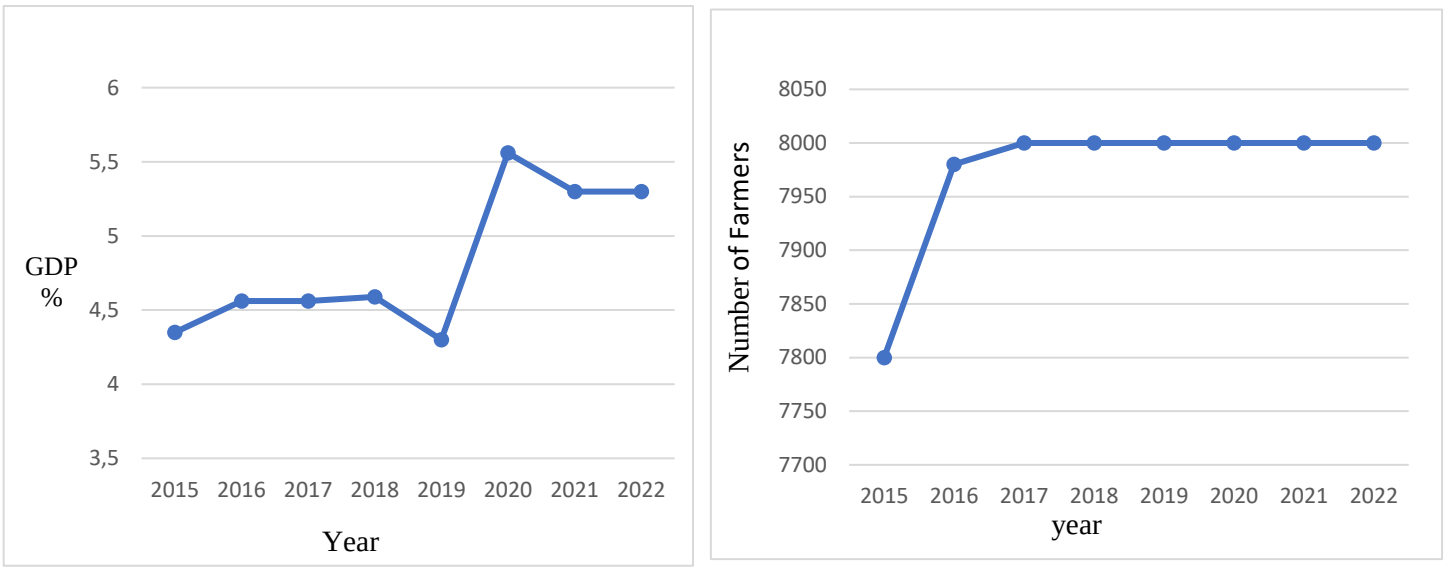
The Maldives is a chain of 1192 islands to India's southwest, one of the smallest countries in Asia and the Pacific by population and land area. Among these 1192 islands, 196 are inhabited, where 112 islands are developed for tourism and are used for agriculture and other livelihood purposes [121]. This means people live on only 16% of the islands, with an area of 300 square kilometers. A population of over 515000 people is widely dispersed among these inhabited islands across an archipelago more than 800 kilometers long and 130 kilometers wide. These islands are formed on coral reefs. Most vegetated islands are less than 0.5 square kilometers in land area. In the middle of the Indian Ocean, 80% of the islands are elevated approximately 1.5 meters above the mean sea level, whereas some rural islands are elevated less than 1 meter.

The capital city of the Maldives, Male, has a land area of 2 square kilometers, and according to statistics, 41% of the population lives in this city, where the economic activities are higher and highly developed compared to the island's communities [105]. All the resources and services are concentrated in the capital Male. Majorities of the islands are underdeveloped and need assistance, rendering the economy and the people vulnerable to environmental and external market forces. In contrast, more than 46% of the population lives on islands where life is based within the island communities [105]. The Maldives working age group (15–64 years) comprises 69% of the population, and 5% of the people fall above 64+ years of age group [105].

The Maldives' economy depends on tourism and fishing. The narrow economic activities of these sectors have propelled them to middle-income despite the geographic constraints and usual challenges that a small island economy faces. In the last five years,

economic growth was on average 4.5% per year, mainly on account of tourism and fishing, but also supported by transport, communications, and construction [100], [121]. Continued growth, however, needs to be more inclusive and balanced. The agricultural sector's contribution to the country's economic growth is minimal, yet the government and the people of the Maldives should pay more attention to the industry.

As shown in Fig. 2.1, agriculture and fisheries contribute only marginally to GDP. Besides, this 4 to 5% contribution remained the same from 2014 to 2020. In comparison, recent statistics report that nowadays, tourism and fishing contribute 28.2% and 6.4% of GDP, respectively [41].



a b

Fig. 2.1. Representation of agricultural GDP (a) and labor (b) in the Maldives

Source: compiled by the author according to [41]

Fig. 2.1 also illustrates that agriculture employs less than 10% of the population. This 10% of the agricultural employees include registered and unregistered farmers. These 8000 registered farmers are registered under the Ministry of Fisheries and Agriculture based on the information recorded by the island council administration. Family farming is most critical livelihood and food security source in rural islands [136]. The number of

farmers decreased dramatically in 2014, and since then, the quantity of people who carried out farming activities was almost the same, with little growth till 2020 [80].

Agricultural productivity is restricted by land availability as the Maldives has only a limited amount of area suitable for agriculture [1]. However, the land utilized for agricultural activities has been increasing. Indeed, the land is still available for expansion since the country's potentially cultivable area is estimated at 3900 hectares [98]. Subsistence farming is done mainly by women in their home gardens, where they grow vegetables, fruits, and traditional starchy varieties, to a limited extent, on small farms. Men dominate the production of high-value commercial crops such as bananas, cucumbers, mango, and watermelon [117].

The tourism sector dominates the Maldivian economy contributing 90% of the government tax revenue income from import duties and related taxes [100]. The tourism sector is expanding to the high-end tourism industry and non-tradable tourism-related activities, including construction, transport, and communications, which underline the Maldives' economic development.

The potential growth of the private sector is limited as it is dominated by capital accumulation through investment in resorts, where there is a massive increase in the labor force. Expansion in the agriculture is constrained by the availability of arable land and soil unsuitable for growing a wide range of crops and vegetables.

Though this is the case, agricultural sector contributes comparatively a very small amount to the national GDP and consists of 8000 registered farmers. The operation of small and medium sized agricultural enterprises plays a crucial role in food security, job creation, economic growth, and social stability of these island communities [116], [121].

The agricultural sector has long been the most important source of food nutrition security and source of income for a large part of the communities in many countries. It has sustained the livelihood of these communities and maintained their natural resources. Similarly, though the agricultural sector contributed relatively little to GDP in the Maldives, it plays a crucial role in enhancing the livelihood of communities, primarily

those residing on the islands. It provides food security, nutrition, and a way of earning income. Farming activities are the primary source of livelihood and food security for 46% of the population living in the rural islands, where they also depend on natural resources such as making baskets as an activity of handicraft [1], [89].

As shown in Fig. 2.2, 53% of the farmers use their products for daily consumption, and 43% sometimes consume their produce. Only 3% of the farmers conduct farming activities for marketing and earning an income [90].

This shows that most farming communities are subsistence farmers who can only produce to meet their daily needs. The lack of importance given to the agricultural sector and poor farmers' capacity, coupled with market inaccessibility and lack of farmers' awareness, keeps the farmers trapped without any growth or significant economic benefit. Fig. 2.2 also depicts that only 1% of the farmers operate during hardship. It means that this percentage of farmers depends on other activities such as tourism, fishing, and construction as a means of living [90].

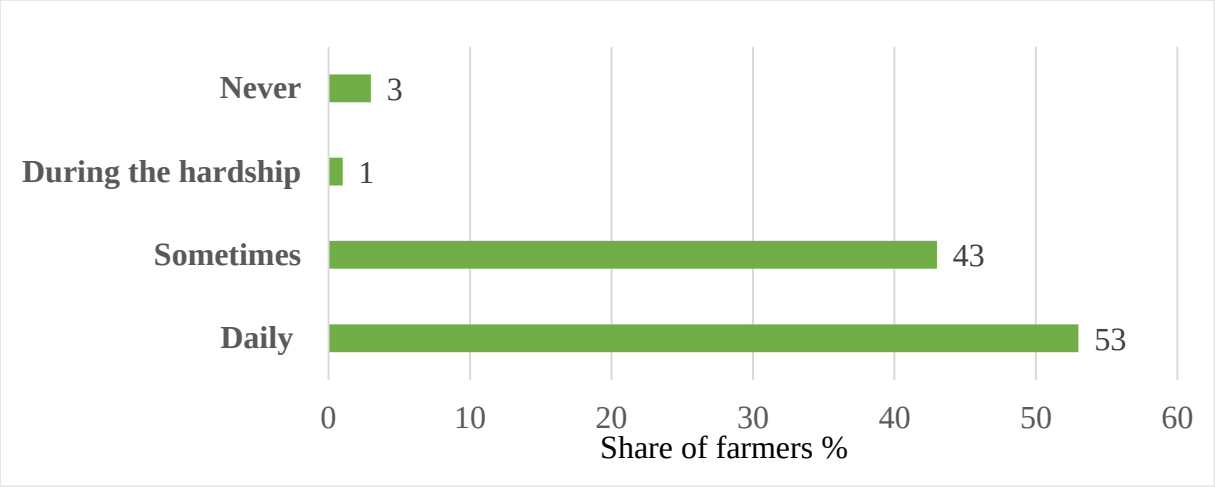


Fig. 2.2. Frequency of household consumption of their farming produce

Source: compiled by the author based on [90]

Till 2018, some of the farming communities of remote islands had no means of transport available to possible market points near them. This also prevents farmers from producing for market purposes as it goes to waste. Hence, most of the farmers can have

enough for their daily needs. Since the beginning, farmers who carry out farming activities extensively depend on the middle person to sell their produce to the market as it is expensive and takes time for the farmers to travel between the market points.

As shown in Fig. 2.3, 88% of the farmers sell their products independently, meaning they sell to the local communities as they can't reach other market points. 11% of the farmers sell the leftover produce through the middleman.

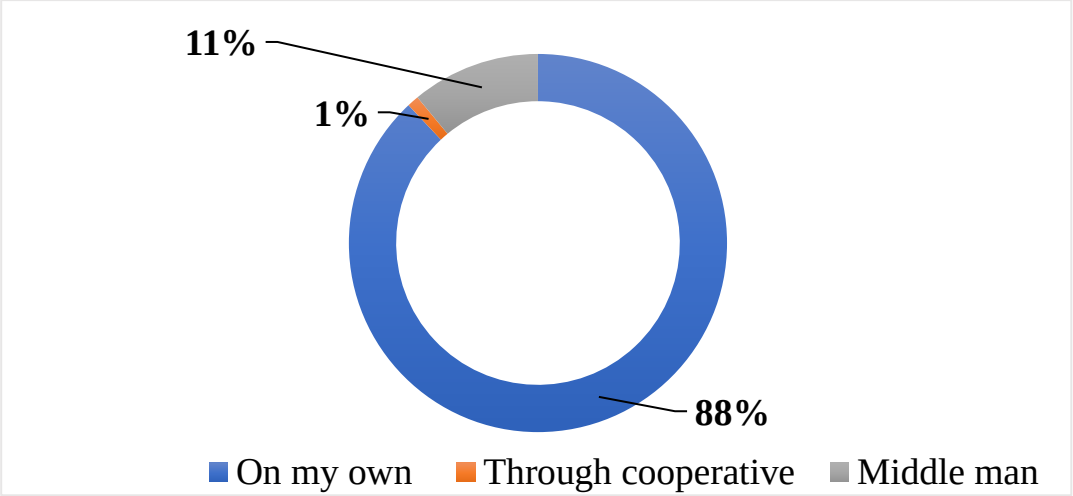


Fig. 2.3. Representation of how farmers sell their produce within the island communities

Source: compiled by the author based on [90]

The middleman collects the produce and transports it to the market points. A comparatively smaller proportion of farmers use the middleman to sell their leftover produce than the farmers who practice selling their produce on their own to the local market [90]. Around 1% of the farmers sell their produce through cooperatives connected to the resort markets. These farmers are economically strong enough to produce for the latter and depend on other means of income, such as fishing and tourism, to support their families [90].

The family farming communities need access to market information. The benefit they gain from selling their products through this middleman is negligent compared to the

time and money they put into producing. It traps the farmers in a vicious cycle of stagnant growth with a lower quantity of poor-quality make with no economic benefit. These local farming communities have long been practicing traditional farming methods, with the recent introduction of miscellaneous types of fertilizers, chemicals, and pesticides to their farming methods [7].

Farmers don't have access to farming tools and equipment, which decreases the efficiency of their farming activities. Women farmers are further marginalized as they do not get enough time to attend farms and are bound to household chores. As shown in Fig. 2.4, only 1% of the farming population can access the irrigation system.

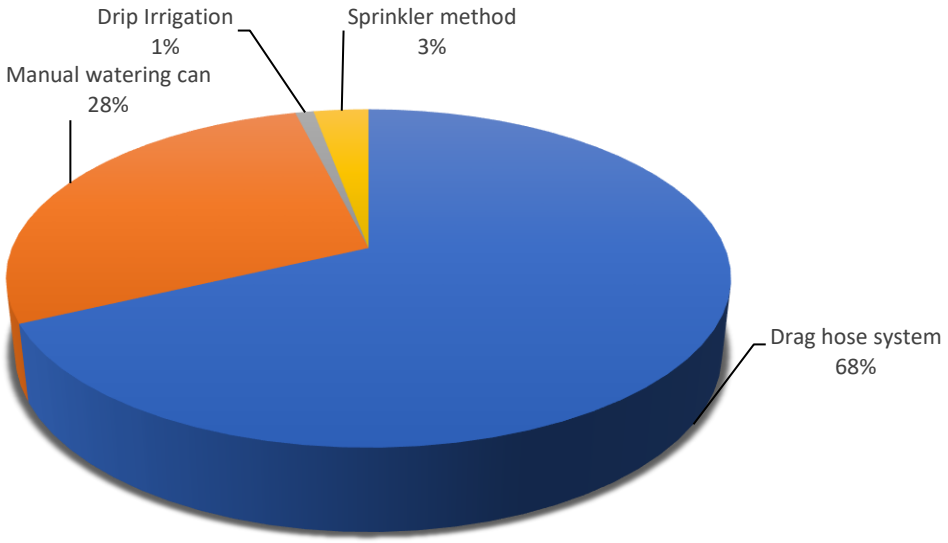


Fig. 2.4. Representation of how farmers water their crops

Source: compiled by the author based on [90]

Fig. 2.4 also reveals that most farmers water their crops manually using a watering hose and watering can, which could be less efficient and time-consuming, indicating that farmers need access to farm tools and equipment to enhance their production. This is because farmers need to earn sufficient income from their farming activities to invest in buying farm tools and equipment. Also, farm credits are unavailable and inaccessible to

move away from labor-intensive methods to more efficient farming activities [90]. Subsistence farmers who grow crops such as papayas and bananas do not water their plants because they need to earn more to invest in the watering hose and the water pump. Not only do they need money to buy this equipment, but most of the farmlands are far from where people live, and there needs to be electricity to run the pump. Petrol or diesel pump is far more expensive as fuel prices are high.

Watermelon has a high resort market, and farmers with easy access to it can sell their produce and earn an income. Such farmers invest in their farms by establishing sprinkler systems. However, as shown in Fig. 2.4, this is a small proportion of farmers compared to the farmers who carry manual watering of plants.

The constraint of land availability is faced throughout the farming communities. Maldivian statistical reports didn't properly record the land area of the farming population until 2018. According to the present data of FAO statistics (see Fig. 2.5), the available arable land size of the Maldives was 3900 hectares under annual crops, while perennial or permanent crops were grown on 1500 hectares [97]. However according to the national statistics, 2371 hectares of agricultural lands are used for commercial agricultural purposes on 188 inhabited islands run by resorts. This is because, over the years, areas suitable for agriculture have been allocated to more profitable tourism sector-related activities [90], [98]. 1529 hectares of farmlands are actually utilized for housing on 90 inhabited islands. The most successful agricultural cooperative Addu Meedhoo operates on 105 hectares, other famous cooperatives with farmlands of around 15 hectares each are F. Magoodhoo, Vaadhoo, and Kaashidhoo Green. The largest individual male farmer Maafahi runs business on 99 hectares. Farmlands of the largest individual female farmer Baa. Anhenfushi amounts to 20 hectares. Other individual farmers cultivate below 10 hectares of land area under annual and perennial crops, where 69% or over 800 hectares are used illegally without proper permits, certificates, council documents and with a lease period of less than 6 months [59].

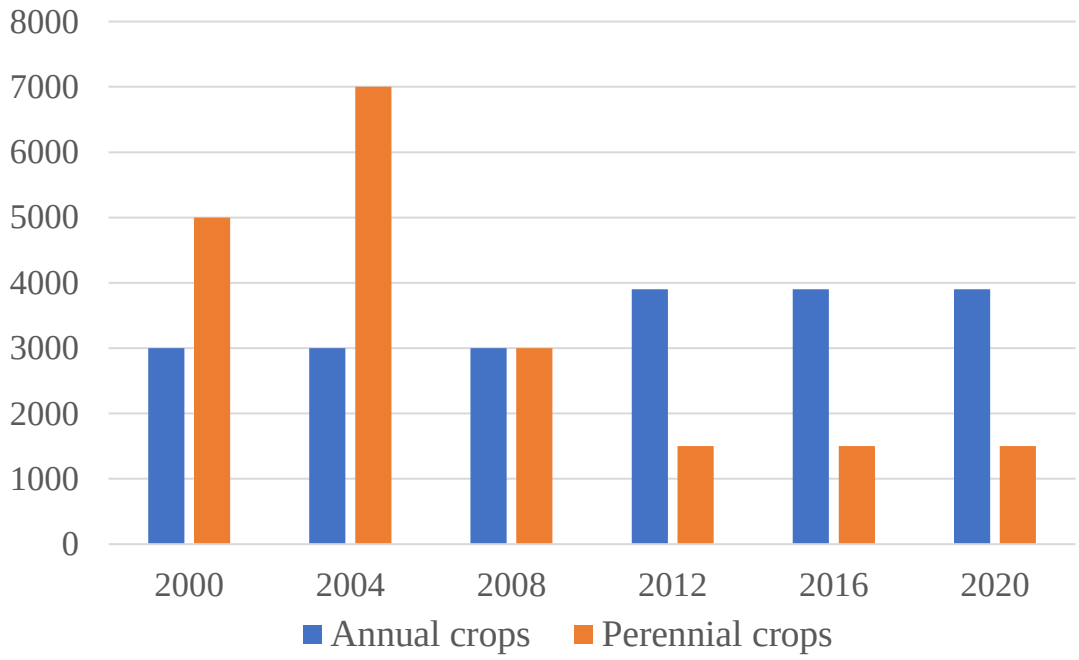


Fig. 2.5. Dynamics of Maldivian farmlands (in hectares) in 2000–2020

Source: compiled by the author based on [98]

Also, the island erosions, tidal waves, and tsunamis damaged most of the arable land areas by washing away the soil top layer and increasing fresh groundwater salinity. As a result, it leads to decreased availability of farmland areas for the farmers. Moreover, within the island communities, farmers who used their backyards and land areas to cultivate crops utilize them now for another housing purpose, decreasing the land area available for farming [120].

The agricultural production of crops such as banana, breadfruit, brinjal, cassava, chilies, coconut, papaya, pumpkin, sweet potato, watermelon, yam, etc., provided healthy nutrition for the communities. Other non-food items such as betel leaf, cordage, and timber were delivered to build shelter and medicine [117].

Since the beginning, the Maldivian farmers have been applying conventional farming methods, and most of the farmers practice farming based on the knowledge

passed to them by their ancestors. Farmers do not have much expertise in selecting quality seeds or applying fertilizers and chemicals. Many farmers follow the instruction on the label and application of fertilizers based on what they think would be the best amount. Women farmers who mostly make the application of fertilizers and pesticides do not take any protective measures. There is no record, yet there are instances where the application of chemicals and fertilizers has killed the growth of crops because of excessive use [7].

Almost all of the Maldivian rural population depends on groundwater (well water), and some farmers run rainfed agriculture, as shown in Fig. 2.6. The Maldives has a very thin underground freshwater layer, and water quality changes seasonally. In some islands, the groundwater layer is contaminated with fecal matter, and extensive use of chlorine is also observed as the locals use this water for drinking [90].

Though most farmers depend on groundwater, the water quality could be better for farming purposes, which hampers the growth of their crops. In some islands, the water layer is contaminated with the overuse of fertilizers and chemicals, which makes it unsuitable for farming purposes.

According to Fig. 2.6, 27% of the farmers do not water their crops as they have no access to fresh groundwater or means of collecting and storing rainwater. The Maldivian islands could not store locally grown fruits and vegetables until 2022. All the islands depend on imports, whereas the urban population relies heavily on imports of food products.

Essential staples include rice, flour, sugar, oil, and fresh produce. Leftover vegetables and fruit, where available, are sometimes sold by rural people to cities [121].

The Maldives is exposed to tropical storms/surges, swell waves, gale-force winds, heavy rainfalls, droughts, tsunamis, and earthquakes [106]. The geographical location of the Maldives makes local agriculture and farming activities highly vulnerable to natural hazards. This put the whole nation at stake regarding food and nutrition security.

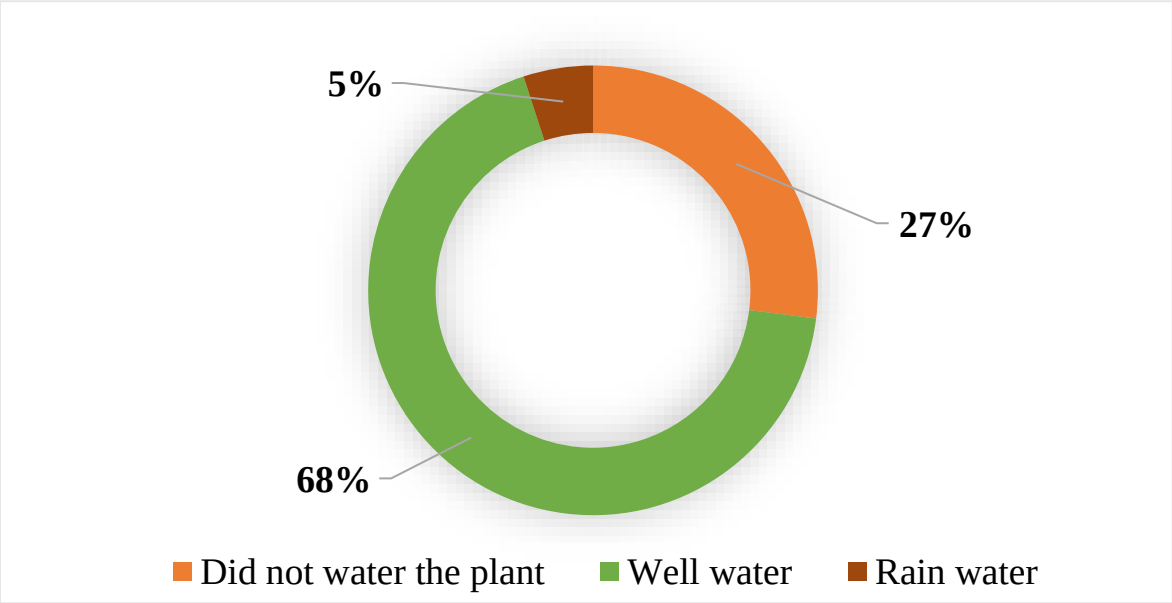


Fig. 2.6. Access to water resources and how watering crops is carried out by the farmers

Source: compiled by the author based on [90]

Nearly 50% of all housing structures are also within 100 meters of the coastline. This low elevation and the small size of these islands make the human settlements defenseless against extreme weather events, as retreating inland or to higher grounds is impossible [152]. Reports also show that even now, crop production is negatively impacted by climate due to reduced water availability and the salinization of aquifers, loss of land through sea-level rise, and plant heat stress due to higher temperatures [54]. The temperatures surplus food they produced, and things such as cordage were sold to earn income.

However, the population has doubled over the past years, increasing the demand for food and nutrition. As depicted in Fig. 2.7, the country shifted towards importing all the food products. Farming of local foods slowly diminished among rural communities as it did not meet the growing demands of their families and is unable to earn an income.

Over the years, the country has observed a decrease in individuals involved in farming as people needed to provide viable income to their families [90].

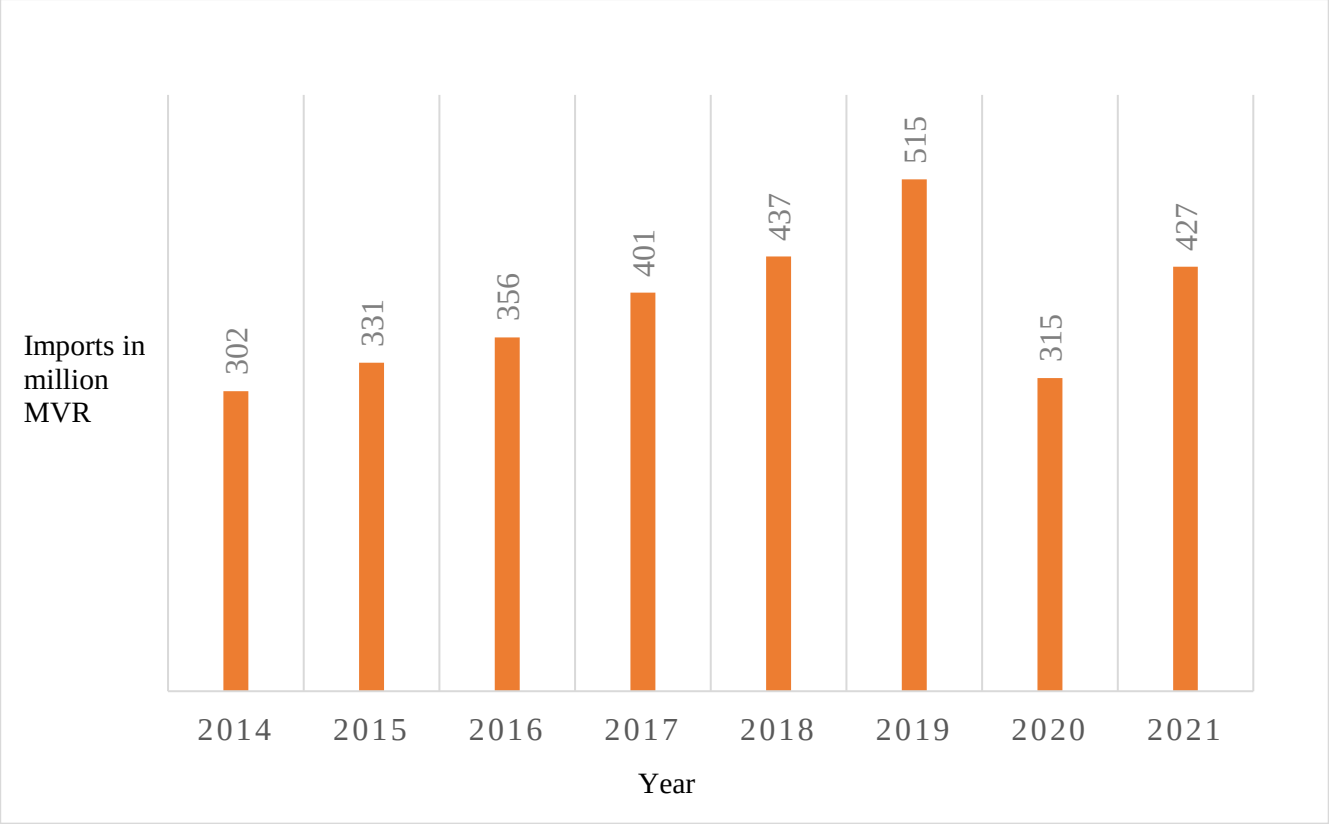


Fig. 2.7. Food imports in the Maldives in 2014–2021

Source: compiled by the author based on [1]

Being the country, whose economy is based on fishing and tourism, the Maldives was driven towards precarious food insecurity. Fig. 2.7 shows a 26% increase in the number of imported products of locally grown crops to meet the consumption demands of the residents. Indeed, from 2014 to 2019, imported food products gradually increased. This is because the tourism sector flourished over the years, along with the growing population, boosting demand for food products, including locally grown fruits and vegetables. This clarifies the need for more capacity to meet the nation's orders and that

poor production of farmers cannot meet the increasing demand put forth by the growing population [1].

Given the limited economic base, the Maldives must invest and enhance the agricultural sector for the country's sustainable development. The government has attained its status as an upper middle-income country, where the Maldivian national poverty line is 74 MVR, which is $5 per individual as a daily expense [76], [105].

Studies show that more than 55000 people fall below the poverty line, meaning that are not able to carry out economic activities which meet the national poverty line standard (see Fig. 2.8).

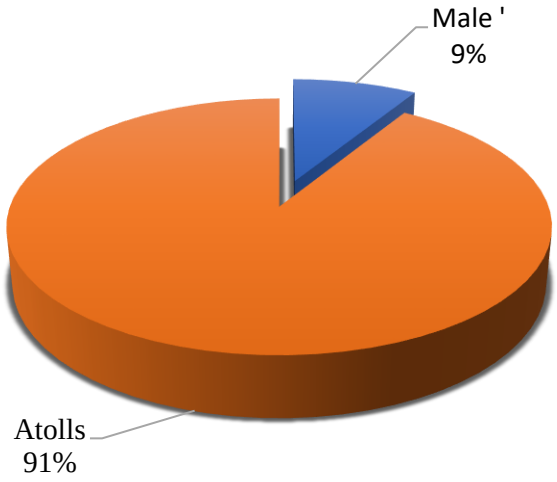


Fig. 2.8. Representation of the poverty-stricken population in the Maldives

Source: compiled by the author based on [76], [105]

Lower income means reduced accessibility of nutritious diet, because in the Maldives more than 90% of the food products are imported and island communities are geographically dispersed away from the capital city.

The poverty-stricken population is unevenly distributed among the islands and the capital. A remarkably high percentage of the poor population lives within the island communities compared to the capital city. Within the island communities, 48800

individuals have no access to a healthy diet, and in the capital city of Male, 6500 individuals are in a similar condition [76]. Based on this, there are almost 55300 people who fall below the national poverty line.

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The vast proportion of poverty-stricken communities within the island's society is due to a lack of opportunities to earn a viable income, undeveloped infrastructure, and lower educational qualifications of the individuals. As shown in Fig. 2.8, only 9% of the poverty-stricken population lives in the capital with more economic activities than in island communities. In contrast, 91.1% of the poverty-stricken population lives within the island communities. Among this population, almost 80% of the individuals practice subsistence forms of farming [76].

It is also observed that women farmers and the island communities' female population are more disadvantaged. This is because women who are already marginalized become more left out due to poverty exacerbating the situation. However, from their farming activities, they cannot meet their daily requirements reflecting the importance of the agricultural sector for the nation's economic development.

In other sectors, female employment is also lower than 30%. It shows that the women's unemployment rate is twice as high as men's within the islands, as there are no employment opportunities other than fishing and tourism in most rural island communities.

The Maldivian food security and nutrition heavily depend on external imports of everything and consequently are really susceptible to external shocks including natural disasters and global crises. This was evident from two recent incidents dramatically

impacting the Maldives, including the December 2004 Tsunami and the COVID-19 pandemic [106].

December 2004 Tsunami swept over the Maldives in an east-west direction. One-third of the country's population was severely affected: 1300 people were injured, 83 were confirmed dead, and another 25 were missing, not to mention destroyed vegetation and farming crops that left the country in a challenging economic situation [106].

Similarly, the sudden outbreak of COVID-19, which caused a lockdown of the borders, worsened poor economic growth further and decreased economic activity. According to Maldives Monetary Authority (MMA) annual report, the economy of Maldives decreased by 32.0%, an estimated 24.7 billion MVR [101].

The tourism industry jobs provided a vital source of income for many families where the decline in the tourism sector left many jobless and drove into a financial hardship. The situation was further worsened by the increase in food prices [99], [106].

Lack of availability and accessibility to food sources and no means to earn an income pushed many working populations both men and women to carry out the farming activities in their home gardens and in available land areas [136].

No record of the Maldives poverty ratio is captured in the national database beyond 2019. During COVID-19, there was a massive disruption in the food supply. COVID-19 and situational analysis report done in 2019 shows that the population with no access to food and nutrients alone hit 5.4% (28840 people). This percentage excludes the poverty-stricken community in terms of monetary basis. The Maldives' poverty share in terms of food and nutrients during the COVID-19 crisis has exposed the Maldives' food import dependency level. To mitigate food shortages, the government had to charter flights to large importer countries such as Thailand, the UAE, and Sri Lanka for importing food [136]. The vulnerability of the country to climate risks and external shocks, the scarcity of primary agricultural resources, and the vast gender gap that exists between females and males show the weaknesses of the farm sector country, which makes up the livelihood of

46% of the population. This confirms the importance of investing in agricultural sector development for Maldivian's sustainable economic growth [146], [159].

The country needs to diversify its economic base, which can be achieved through investing and developing its agricultural sector. This will help the government move towards sustainable economic and social development. Strengthening the country's agricultural industry will diversify the economy by increasing local production, providing job opportunities to many, and adding value-added financial and business services. Most importantly, it will maintain the country's food and nutrition security.

Agriculture is a critical component of food security in the Maldives. Due to the country's geographical location, most of its food is imported. However, the Maldivian government has recognized the importance of local food production and has been working to increase agricultural productivity. According to the Food and Agriculture Organization report, the government has been promoting the cultivation of vegetables, fruits, and other crops, focusing on increasing the production of staple foods such as yam and cassava [50]. This emphasis on food security is critical for the country's sustainability, as it reduces the reliance on imported produce and ensures that the population has access to nutritious and affordable food.

All the above makes it possible to conclude the following. To ensure food security and sustainability in the Maldives, it must implement family farm management measures to integrate sustainability dimensions, as shown in Fig. 2.9. That is, the development of the agricultural sector must consider family farm management in the economic, social, and environmental dimensions, which drive the industry toward sustainability. As part of the economic dimension agricultural labor force must be built and strengthened in terms of their skills, knowledge, and financial capacity. Developing and recruiting the young population into the farming sector, as labor force recruitment, is a way of strengthening the social segment of the farming industry, which will create employment opportunities, where these farmers can be supported through consulting services [152].

Through the environmental component, farming communities must be fostered to adopt environmentally innovative farming methods to address climate instability challenges. Farmers need to be educated to take measures to sustain natural resources, such as water, soil, and nutrients.

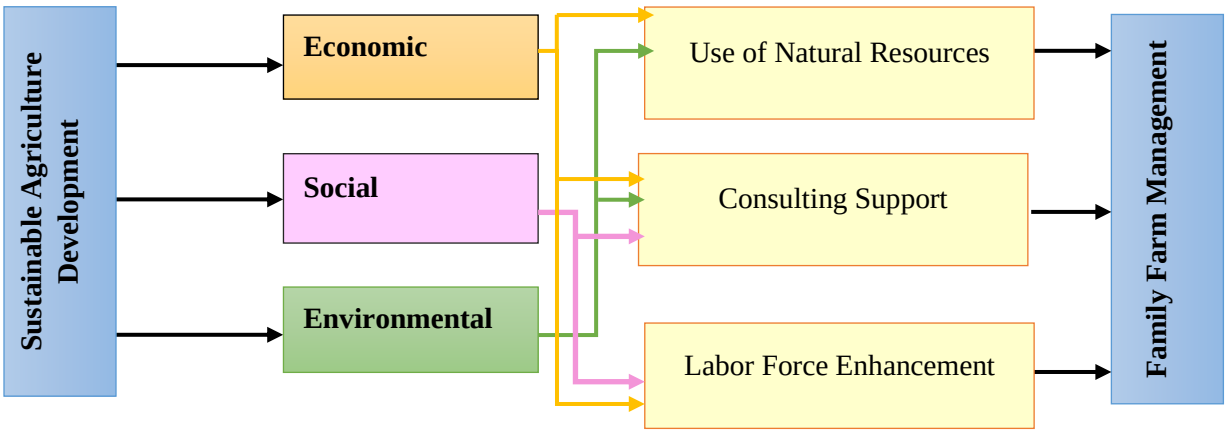

Fig. 2.9. Key directions to improve family farming for sustainable agricultural management in the Maldives

Source: compiled by the author based on the research study

Consulting service is a priority aspect in farm management as it is essential in guiding and advising individual farmers, farming associations and farm entrepreneurs in the right direction when managing their resources and capital in the most economically, socially, and environmentally sustainable manner.

With such an approach, farm management must be undertaken as a holistic approach that considers and takes appropriate planning, organizing, and controlling measures to address social, economic, and environmental challenges the farming communities faces, along with consulting services pushing the sector toward sustainability.

2.2. Features of family farming in the Maldives: influential factors and trends

Farming in the Maldives, as discussed above, is carried out for two purposes, which include a means of obtaining required food and nutrition as well as a means of earning profit. Farmers residing in rural island communities have been investing their time and money to increase their production and make a profit to earn a living. However, with the need for agricultural infrastructure, farming communities have to work hard to gain access to agricultural inputs, reach out to market points, and provide appropriate production quality. There is no chance of fulfilling it without the country's government giving more attention to building the national agricultural sector.

COVID-19 was a wake-up call to the whole country. The experiences difficulties when importing food products and transporting them within the country between geographically separated islands forced many farmers who had left their farmlands barren for years to pick up their shovels and plow the land. Many private and individual businesspeople began supporting local farmers by providing expert opinions and training to the farmers who buy their agricultural inputs such as fertilizers, chemicals, and pesticides. Currently, there can be seen a bloom of private farm enterprises that support farmers in providing information and opinions on how to grow crops.

This gave hope to many farming communities, and farmers started producing exclusively for market purposes. Many farmers are passionate about their farm business and take risks to grow it. Private and government agricultural enterprises formed to support farmers are at the very early stage of their development. These family farmers face many challenges which need a complex investigation that can be provided through PESTLE analysis covering the following six macro-environment groups of factors [6].

1. Political factors analyze government regulations in import and export, labor and tax legislation, competition, consumer, and environmental protection laws related to farming.

2. Economic factors affect the country's economy, including inflation, gross domestic product, interest, exchange rates, and unemployment, directly impacting agriculture.

3. Social factors are about the population age, gender, number, natural increase, birth rate, mortality, migration, and education level affecting nature and progress observed in the agricultural sector.

4. Technological factors analyze technological advancement, which influences the promotion and continuity of the agricultural industry.

5. Legislative factors are linked to the institutional framework that develops into a business environment and operates in the agricultural sector.

6. Environmental factors cover technological solutions and policies to preserve the potential of ecological resources in farming.

By and large, Political, Economic, Social, Technological, Legal, and Environmental factors analysis (PESTLE) is a strategic management tool used to identify, track, and assess the changes and to what extent these changes have an impact on agriculture. It is an effective tool for understanding and analyzing the surrounding and macro factors that may profoundly affect the organization regarding opportunities and threats. These factors have a significant role in transforming the whole competitive situation of the industry. Analyzing the macro factors using the PESTLE analysis helps the managers or decision-makers align with the external environment, leading to long-term success for the organization [6].

Through PESTLE analysis, the decision-makers can identify the current factors affecting the organization and forecast ones influencing the organization to adjust management strategies to address the forthcoming. Most importantly, it helps the decision-makers determine and utilize opportunities to benefit the organization and address threats beforehand [6], [129]. I.I. Vinichenko, N.V. Trusova, S.V. Kalchenko, O.S. Pavlenko, et al. argued that both macro and micro factors affect competitiveness and continuity of small agricultural businesses. That is why miscellaneous approaches focused

on identifying farming risks can support sustainability in terms of adequate resource management and profitable economic performance [174]

The PESTLE analysis is invaluable for organizational change, where farmers must take strategic measures to enhance the quality and quantity of agricultural production to meet the constant growth and demand of the competitive market. By doing this, the organization can improve its methods and move towards advanced technologies to enhance its products [129].

Understanding the influential role of macro factors and how they impact the set objectives maintain strategic planning that allows to make business decisions that optimize the use of their resources according to the macro environment dynamics, fluctuations, and trends. Moreover, it helps the organization to align and develop the available human resources to address the skill gap moving forward with advanced technologies [129].

PESTLE analysis is a tool used as a situational analytical instrument for business evaluation purposes. It is one of the most used models to assess the external business environment that is highly dynamic. This approach helps the managers to understand their market position and determine key aspects to update targets, and performance schedules as a part of risk ascertainment and strategic response to provide future development [20].

In this regard, the PESTLE model analysis is carried out in farming to understand core restrictions, opportunities, and challenges in developing and managing the small family farming communities towards sustainability. This is because such analysis further identifies the future macroeconomic variables of interest in the construction of different scenarios of business through policy initiatives [20]. It involves considering the external environment before starting a project to capture all potential risks and issues.

In this study the PESTLE analysis is done on the agricultural sector of the Maldives in two steps. Firstly, it identifies the PESTLE factors surrounding the farm business by reflecting on the external environment through the available literature, such as government policy documents, newspaper articles, reports, and information on official

institutional sites, and secondly how these factors affect now and will affect Maldivian farming in the future. The relevant research findings are as follows.

Political factors interact with agricultural systems, both directly and indirectly. Politics directly influence agriculture through the associated regulations and property rights constraining management options. In contrast, politics indirectly affect the agricultural sector through subsidies for agricultural production, conservation measures, and government investments in public infrastructure [20].

A prime political factor is political stability. The Maldives have experienced political turmoil in the past few years and gained politically with the election of the new president on September 11, 2018. The Parliament of the country passed a budget of 37504 million Maldivian Rufiyaa (MVR) for the year 2020, from which 21% was allocated to the economic development of the country, including tourism, fishing, and agriculture, mainly focusing on developing small and medium-sized business enterprises [6], [41].

The budget allocation for the agricultural sector alone needs to be higher, which is a worrying situation given the poor growth of the industry. The 2004 Tsunami incident showed the country's food and nutrition security vulnerability, where the government was adversely affected in terms of the availability of food and nutrients given that the farming communities have no storage to store their farm produce [6], [103], [106], [110].

The Maldivian Strategic Action Plan 2019–2023 is based on the Maldivian government's central policy and has placed importance and development directions towards transforming the country's agricultural sector. This means the advancement of potential major agricultural islands, developing at least 20% commercial farms, recruiting at least 1500 farmers and ten agricultural enterprises, including 300 women farmers who are benefited from the SME loan schemes [121]. However, due to differences in political opinions, and the segregated multi-party system, it isn't easy to move toward the government goals. Under the government's decentralization policy, each atoll and its resources, such as lands, are governed by the council and have members from the ruling

and opposition parties. As a result, there is less support and difficulty in implementing policy initiatives on most islands [155].

Another essential political factor is market access and land security. The tourist resorts and the domestic market are the Maldivian farmers' primary markets. The tourist market determines the rising demand for fruits and vegetables local farmers grow through the ever-increasing tourism sector. However, given the inefficient transport system farmers must pay a lot to transport their products. Only some resorts provide transportation from their production site. Thus, most of the farming communities need a means of transportation. Regarding the domestic market, local produce distribution from the islands to the main market center, the capital city, is established through intermediaries and wholesalers. However, this adds extra cost to the price of locally grown fruits and vegetables, making them less attractive. Unfortunately, the government has no regulation or policy to ease farmers' burden in bringing their products to the market [6].

Land security is another big issue strongly influenced by each island's local governing system. Although the Land Act passed in the Maldives helps farmers rent the lands for farming purposes, the regional governing offices determine the consistency and availability of land for agricultural purposes based on their interests and political agendas. The rent of the land is high, which does not meet what the farmers gain from farming and the cost of producing it. How the land leasing is greatly influenced by political leaders and is mainly leased to powerful political parties marginalizing the local farming communities [6], [114].

Taxation policy and subsidies manifest themselves through the following. The government of the Maldives has abolished all the goods imported for agricultural purposes and introduced short-term loans to enhance farming growth [16]. However, this has affected the agricultural sector adversely. There is a tremendous increase in imported cheap fertilizers, especially untreated cow dung, pesticides, and farm chemicals. Lack of knowledge about using these imported fertilizers to cultivate small land areas has led to overuse, soil degradation, groundwater contamination, and depletion.

As shown in Fig. 2.10, pesticide imports increased from $3.07 million in 2019 to $5.33 million in 2021. In 2022, pesticides decreased to $4.28 million [51]. There are undocumented extreme cases of fertilizer misuse, such as the outbreaks of diarrhea and skin diseases among the island communities due to the contamination of the water layer by fertilizers and pesticides. Looking at the positive side, the reduction of the taxation policy has helped farmers increase their production yield and produce quality fresh vegetables and fruits by using modern imported fertilizers and seeds.

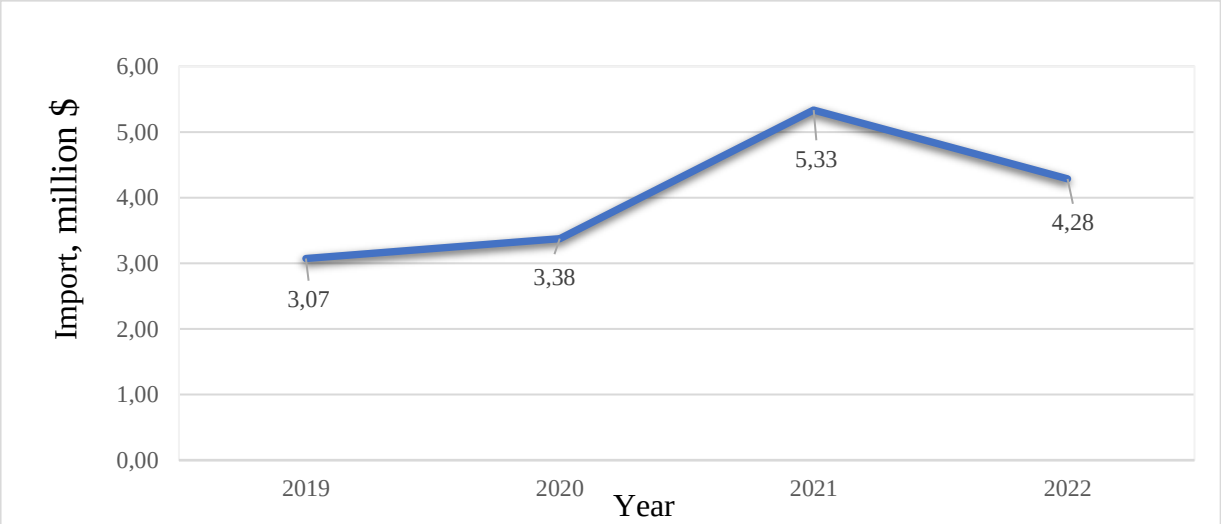

Fig. 2.10. Dynamics of imported pesticides

Source: compiled by the author based on [51]

Another influential political factor is the Farm Safety Net. The government SME policies aim to develop training facilities for those who wish to acquire knowledge and skills in business activities such as farming and agri-business [120]. But a detailed strategy or plan needs to be outlined to achieve this. Indeed, no policy or law is in place to protect the farmers from economic forces beyond their control. No crop insurance policies are introduced to assist farmers in recovering from damages caused by natural calamities such as floods and high waves, the two most common forms of natural disasters that impact farming communities in the Maldives.

Besides, no law or policy encourages farmers to use innovative farming methods and conserve natural resources. Nevertheless, with the help of UNDP and initiatives taken by the Agricultural Ministry of the Maldives along with some farming communities, there is a growing interest in aquaculture farming methods. Most Maldivian farmers who use traditional farming methods need to gain the skills and knowledge required to adopt this method of agriculture.

For example, hydroponic farming was implemented on two inhabited islands of Maafushi and Thoddoo. This way an estimated 41 types of fruits and vegetables are being grown in Maafushi, and Thoddoo is identified as the Maldives' most significant producer of watermelons [77]. This could be an option to increase production for a country like the Maldives with the limited land capacity. But still there is no policy or plan to develop this farming method on other islands.

The Maldives Food and Nutrition Safety Policy was implemented in 2017. Although the policy clearly outlines the roles and responsibilities of various stakeholders, it needs to be adequately implemented. There needs to be more consistency in quality monitoring, inspection, and testing of the fruits and vegetables imported to the country. It is impossible to achieve the objective of the Food Security policy since there are limited human, technical, and financial resources to fulfill the purposes of the procedure [122]. This issue of imported fruits and vegetables from India and Bangladesh is becoming a massive concern for local farmers. As a result, the Maldivian market is flooded with cheap, low-quality vegetables which are artificially colored to enhance the appearance, and which are contaminated with residues such as biological, chemical, and physical contaminants. This impacts health and food security and diminishes the demand for locally grown fruits and vegetables. There is no policy or regulation to tackle this issue.

A country's economic performance determines a company's performance, and the results resonate with long-term effects. This includes the inflation rate, interest rates, foreign exchange rates, and economic growth patterns. For example, the inflation rate

dramatically determines how the company price is selected and the purchasing power of a consumer and changes demand/supply models for that economy [121].

One of the core economic factors is agriculture credit which is outside the priorities for micro-finance institutions as it is perceived as a poor growing and low-profit sector. The SME and commercial bank loans for agriculture are less than 1%, and most commercial banks need to be in a volunteer position to lend sufficient finance for the investment needs for farming development. Long maturation periods, lack of trained technical staff to identify the potential activity in this field, and poor eligibility are some of the primary reasons behind the insufficient credit flow to the agricultural sector.

In addition, through the "Fund Management System" and Agricultural Ministry, there are loans targeted at farmers who wish to develop their farming businesses. The eligibility criteria of this loan system are designed so that a middle-income or low-income farmer, especially one living in the island community, will not be able to acquire it. Discussing with some of the farmers who have invested a considerable part of their life in growing agricultural products and are in connection with other farming communities has stated that most farmers are unaware of how to attain these loans. Most farmers show no interest in taking and investing in these loans due to high-interest rates and land insecurity. Also, attempts to initiate commercial agriculture ventures often fail because locals do not possess the means to procure financing to start profitable agricultural projects.

The Maldives' agricultural sector has little impact on the country's economic growth. It is significantly affected by the country's changing and fluctuating financial situation due to its low productivity and little contribution from the government. In the Maldives, 95% of the food consumed is imported, including sources of macronutrients, i.e., carbohydrates, protein, and fat. Wheat flour, refined sugar, and non-alcoholic beverages are among the top commodities imported in significant quantity [105]. In the contrary agricultural product exports are next to nothing due to low productivity in the Maldives.

According to World Bank data, in the Maldives, inflation has fluctuated and increased gradually over the past three years. It has remained low at 0.22% in 2019, benefiting from the global decline in commodity prices and the pegged currency regime. In 2020, inflation decreased to –1.37% but rose to 0.54% in 2021, caused by low aggregate demand, low oil prices, and continuing price subsidies on utilities. In 2022 inflation in the Maldives was 2.3% [104].

The government of the Maldives imposes price cuts on major staples and reductions on import duties primarily related to the economic activities of the communities to counter higher global prices and fix prices for transportation and utilities [121]. The chronic budget deficit and public debt gradually increase yearly, resulting in declining profitability for the local agricultural farmers and purchasing power parity. Studies show that significant disparities in welfare and other socio-economic outcomes persist, with over 90% of poor Maldivians living in atolls who depend primarily on agriculture to earn income and sustain life [99].

The fluctuating and gradual increase in inflation might benefit local farmers by raising the prices of their products than for inputs. This might increase profitability for the local farmers as there will be a constant demand for agricultural products depending on the tourism sector’s growth and occupancy.

Input price inflation in terms of fertilizers and farm-related commodities will create cash flow problems for farmers as this will increase the cost of production. Individual farmers can counteract the effect of input price inflation through productivity increases and cost economizing. However, the local farmers are challenged by the limited land availability and low productivity.

Even if it is in decline, the current account deficit remains significant, especially given the low level of international reserves and the growing exposure to international creditors. Commodity prices also have a remarkable effect on state debt and will be negatively impacted by the increase in oil prices. This will induce a risk of pressure on the Maldivian currency Rufiyaa and, by extension, a threat from the amount of external

debt denominated in foreign currencies, especially in a context of an appreciating US dollar and global monetary tightening.

The financial statistics of the country show that the country has projected a total budget of 34.8 billion MVR for 2021. The government is estimated to receive 17.8 billion MVR as revenue and grants. However, the government expenditure was too high, 33.3 billion MVR, including 1.5 billion MVR as loan repayment. Therefore, the government budget deficit was 15.5 billion MVR or 23% of the Maldives' GDP [114].

Regarding employment rate, the Maldives has one of South Asia's lowest labor force participation rates. Unemployment increased from 4.56% to 5.26% from 2019 to 2021 and slightly decreased to 4.9% in 2022 [80]. The 2004 Tsunami destroyed more than 90% of the agricultural land of the farming communities, immensely impacting the livelihood of these communities and further exacerbating the unemployment rate of the country [99].

The fisheries sector contributed low at only 6.4% of GDP in 2020 compared to tourism, yet it remains the most significant source of employment, especially among the rural island communities [99]. Looking at the country's agricultural sector, only 8000 people are employed as the registered farmers. In addition, a handful of farmers supplement their low income by engaging in dual occupations, pursuing farming and off-farm employment, which could be considered part-time farmers.

Keeping aside the low productivity, low income and attitude are the most significant factors reducing the agricultural sector's local labor force. There needs to be formal education and training provided by the educational curriculum of the Maldives, as no certificate programs or higher education opportunities are available in agriculture and farming. As a result, there is a labor shortage and a need for more skilled laborers in the Maldives. According to reports, there is a skills shortage among the local population due to economic growth and comparatively slower growth in education training institutions [117]. The average employment improved in 2022 since the unemployment rate decreased to 4.88% in 2022, which was 5.26% in 2021 [105]. However, the number of people

employed in agriculture dropped as the government invested more in training and developing individuals in other sectors such as teaching, medicine, and tourism [105].

Social factors also matter. It involves operating and functioning in a society affected by the sociological aspects of its market and community. The social factors include demographics, age distribution, attitudes, culture, etc. [75]. Therefore, it is essential to consider how sociological factors impact the agricultural sector of the Maldives. According to reports, the country has moved from the low human development category to the high development category due to improvements in life expectancy, an increase in mean years of schooling, and a rapid increase in per capita national income. The high unemployment and no job opportunities at the rural island level are coupling the nation's unemployment rate limiting the inclusion and productive participation of the youth in the economy. However, recent studies show that there is a probability of losing the socioeconomic potential of the nation as there is an increase in students who are ending school with certificates at the age of 25 to 34. Moreover, 29% of males and 24% of females are without any diploma.

Along with the unemployment rate among the islands, there is a higher poverty rate than that of the capital city. That is more than 90% of the poor lives among the island communities, and there is uneven distribution and delivery of social safety support persists as the average expenditure of the bottom 40% of the population is 2.5 times lower compared to the average of the top 60% of the people, suggesting relatively high inequality. The government continues working towards reducing poverty within the island communities. The official poverty headcount ratio stood at 5.4% in 2019, one of the lowest poverty rates in the South Asian region [110].

Labor Force and Common Belief Towards Agriculture in the Maldives are ambivalent. A study by the Asian Development Bank on commercializing the National Agriculture in the Maldives showed that all the farmers were over the age of 45 years in the islands where the rapid field assessment took place. According to statistics, 74.4% of the Maldives' population comprises people aged 15 to 65. However, the young population

shows no interest in joining or working in agriculture because farming is the least developed sector of the Maldives. There is a long-believed belief in Maldivian society that agriculture is meant for the least educated middle-aged people. The young generation shows no interest in farming. There are underlying valid reasons for the negative mindset of age. In addition, the female labor force participating is lower than that of men. Statistics show that in 2019 female labor force participation was lower than 40%, whereas male participation was higher than 60% [120].

First, the Maldivian community believes that farming is for the least educated and lower working-class people. Secondly, the fact that there is no agricultural enterprise that can provide the necessary aspiration for the young generation coming out of secondary education to consider agriculture as a viable long-term career option. Thirdly, sectoral agriculture/rural development education must be more promoted in the Maldives. Higher education institutions had intended to offer certificate or undergraduate-level agriculture or food production courses by the end of 2022 [6], [14], [80], [114].

The Ministry of Agriculture has implemented a hydroponic method of agriculture, and it is becoming common in some farming communities in which the young generation has no interest. For example, the employees and laborers in the large-scale agricultural hydroponics projects conducted in Maafushi and Thoddoo consist of middle-aged men and women who need formal education [77].

Another influential social factor is gender parity. It shows that the number of men in the agricultural and fishing sector is four times higher than that of women. No statistical data was recorded or available on the number of women and men involved in farming [50]. Women in the Maldives face constraints socially and economically, hampering their development and empowerment. According to the 2019 gender index, the Maldives Gender Inequality Index (GII) value of 0.369 ranked 82 of 162 countries showing the vast inequality among men and women in the nation. Regarding education, males and females have equal access to education up to the primary level. Still, there is a vast difference for women when it comes to tertiary education. Due to the remoteness of some islands and

the responsibilities of women in the family, they are restricted from moving away from their home islands for tertiary education as they are bound to household chores. Females are at the lowest value chain, engaged in home-based income-generating activities. Most young women who complete their primary and secondary education need access to information regarding professional and employment opportunities along with vocational training. Deprived of these, females have to do menial jobs in agriculture and fisheries and hence are economically vulnerable.

In the Maldives, women have difficulty accessing credit to finance business start-ups such as farming that is a major tripping block. In addition, banks accept limited property types, such as land, houses, and ocean vessel, as women-owned loan collateral. As a result, women are stuck at the lowest value chain or only in spillover economic activities. Moreover, females need more information about basic agricultural techniques and the market [90].

A country can only achieve the height of its development, socially and economically, by engaging all the critical development agents. Women play a massive role in providing sustainable financial and social development. According to UN studies, if women were given equal resources and had the same access as men, agricultural output in developing countries would rise by an estimated average of 4%, which could reduce the number of undernourished people in developing countries by 17%, translating into 150 million fewer people [135], [145].

Recently the authorities implemented the Maldives Short and Medium Enterprises Act, which focuses on enhancing women's economic empowerment and prioritizes limiting barriers for females to join the labor workforce, access to loans, and opening opportunities for women's greater participation in agricultural business.

In addition to this, the Cooperative Societies Act was put into force in 2010. It demands at least 20% of women to participate in cooperative societies and requires an annual report about initiatives taken by the collective community to increase the female share. This act is specially targeted to women with limited resources to allow potential

entrepreneurs, especially in the outer islands, to pool their resources for business start-ups, such as retail trade, agriculture production, processing, and marketing.

Recently there has been an increasing trend of engaging cheap foreign labor in the fisheries and agriculture sectors, slowly replacing local women. This will further disempower rural females, as they are becoming economically unproductive. The recent statistic indicates that over 39% of women are unemployed, and when employed, they earn a third less than their male counterparts. Yet, women-headed households and their responsibilities are increasing [111].

Technological factors refer to the technical awareness of a market process regarding automation, research and development. These factors affect the operations of the industry and the market both favorably and unfavorably [137]. In the Maldives, there is undeveloped IT infrastructure and poor connections between the dispersed islands. These geographic conditions in the Maldives pose some challenges, such as inequalities in the internet coverage and, subsequently, a higher concentration of businesses and workers in and around Male. All the sectors, including health, education, fisheries, and tourism, have been suffering due to a lack of relevant services on remote islands which stems from the low levels of capital investment.

Regarding technological factors in the Maldives, the agricultural sector can be considered the least developed sector in the Maldives. Due to the limited availability and less soil fertility, Maldivian farmers are moving towards the hydroponic method of growing vegetables and fruits. However, this farming method requires costly nutrient inputs and intensive monitoring and care. Besides, most farmers need more technical knowledge and skills for farming.

At present, transportation in the Maldives is still inefficient and unreliable. Some farmers who farm in or nearby inhabited islands travel by small boats to attend their crops and return to their home islands in the evening. They need proper storage facilities on these islands to keep their harvested crops until they reach the market. Most farmers need

tools to monitor their soil quality, mainly if they depend on the traditional irrigation method. It is because only some farmers have installed sprinkler systems on their farms.

Food and Agriculture Organization 2017 assessment reports showed that the Maldives' agriculture is significantly challenged by the increasing number of plant pests and diseases, and weeds attacking the crops and the plantations. Some farmers use heavy doses of chemicals and pesticides, leading to water poisoning and, in extreme cases, losing healthy yields [67]. The farmers lack the technical knowledge and technology to combat this issue, and many farmers across different island communities keep voicing their concerns.

There needs to be a legal framework that addresses the concerns of farmers, such as the limited availability of land for agricultural purposes. No law or regulation controls and monitors the type of fertilizers that are being imported into the country, which poses a significant threat to the native crops as well as the soil composition. The government has abolished import tax on agricultural-related products, which, through malmanagement, is leading to the introduction of pests and other crop diseases. The Maldives immigration law and expatriate workers policy is fragmented. As a result, there is a massive influx of cheap labor from Bangladesh and India, employed in the local farms replacing the local laborers. Moreover, the local markets are filled with imported vegetables and fruits from neighboring countries. Their products are sold in the market for a lower price than locally grown ones since the input required to produce local products is high. There is no law or regulation to restrict or lower the number of imported vegetables and fruits to allow local farmers to find their place in the market and improve their business.

The environmental factor is one of the PESTLE factors, including all those that influence or are determined by the surrounding environment. A country like the Maldives must consider environmental factors as a severe issue that significantly influences organizations' performance. The negative impact of environmental factors is one of the primary reasons why the growth of the Maldivian agriculture sector is hampered.

The Maldives is a group of islands merely 1.5 meters above sea level, making it highly vulnerable to flooding and salinization of freshwater supplies due to rising sea levels. The freshwater layer lies just 1.5 meters below the surface, not more than a few meters thick. Groundwater is scarce. According to the NAPA 2006 assessment, the Maldives is at risk of more significant drying and heavy rainfall, increasing the risk of droughts and floods, especially during El Nino events. Tropical cyclones are predicted to enhance in intensity by 10 to 20% in the future [46], [120].

The soil comprises a thin sandy layer at the top, a layer of organic matter 15 to 40 cm deep, and a layer of hardpan 30 to 50 cm deep before reaching weathered bedrock. The soil lacks nitrogen and potassium due to excessive leaching and low fertility. Due to a lack of knowledge and skills, farmers use poor agricultural practices such as overuse of fertilizers and increased usage of cheap fertilizers worsening the situation further. In addition, some farmers leave behind the previously farmed land completely impossible to grow crops [1].

The consequences of such impacts are likely to be more severe on the country's agricultural business as it is already under stress due to climate hazards such as changes in temperature, precipitation, and timing of extreme or critical thresholds. The lower development of the nation is related to climate risks, disaster resilience, and environmental vulnerability coupled with increasing the amount of waste within the capital city and among the rural island communities. It is likely to increase food insecurity in the country, where disaster management and food distribution are complicated due to the geographic dispersion of the islands. Similarly, like the fisheries and tourism sectors, the agricultural industry is also highly climate-sensitive, where the ripple effect will significantly influence the livelihood of 90% of the island communities [121]. The key findings of the PESTLE analysis specific to the Maldivian agriculture are collected in Fig. 2.11.

All of the above urge authorities to address the issues in Maldivian farming. Therefore, the newly elected government has envisioned the development of agriculture as an economically rewarding industry and established Agro National Corporation Ltd as

a subsidiary of the government-owned Maldives Fund Management Company (MFMC). This company was set up on April 21, 2020, with an overall mandate of achieving food security as an economic objective, increasing employment and income-generating opportunities for individuals from agriculture, and re-shaping it with technology [14].

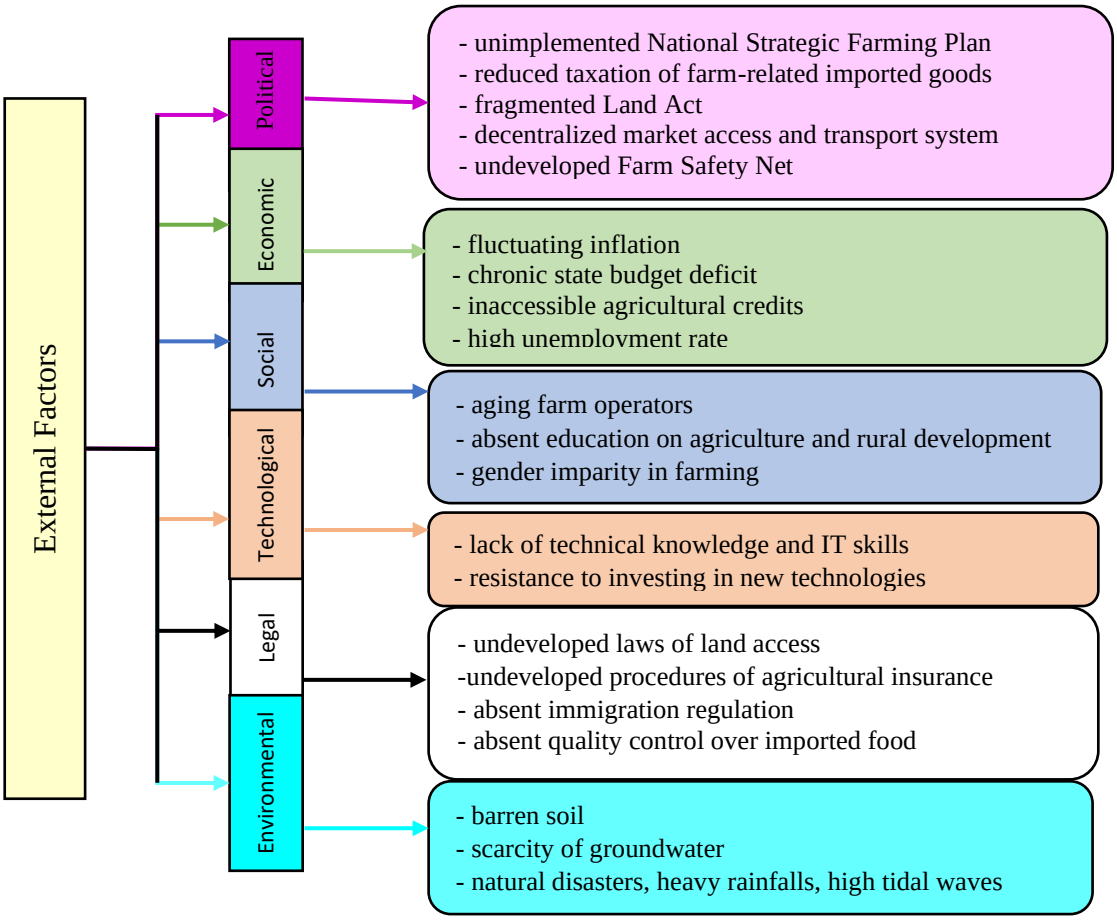

Fig. 2.11. PESTLE scheme of the Maldivian agriculture

Source: compiled by the author based on the PESTLE analysis done [6]

2.3. Regional aspects of contract farming in the Maldives: constraints and challenges

The Agro National Corporation's contract farming model aims to achieve the government's objectives and, through the company's mandate, assist local farmers and

reduce imports of 17 crops (including fruit and vegetables) by at least 50% by the end of 2023. Through this model, based on the small family farmers' contracted size of land and crop, a farmer is given a specific number of required inputs for the chosen crops based on the company's targets. This significantly helps the company and farmers plan and invest in reducing transaction costs and uncertainty around prices and market options [14].

AgroNAT has divided the islands of the Maldives into five regions, from which two agricultural parts remain inactive in farming because of the farmland in-availability. Therefore, AgroNAT targets its support in three areas of the Maldives, where family farming communities are prominent and depend entirely on their farming activities as their primary source of income, nutrients, and a way of living. The company and farmers benefit each other under the set terms.

In particular, farmers agree to provide unquestionable quality and quantity of products to the purchaser, where the latter offers production assistance, input supply, and technical advice. This became an answer to the Maldives family farmers, who were highly restricted by low productivity, unavailability of natural resources such as land and water, and insufficient profits to make profitable investments.

However, it is observed that the family farmers' production and farming activities could be improved despite the support provided by the AgroNAT. According to the AgroNAT report, as of 2020, the company did not benefit during the first two years, showing slow production and family farmers' growth. Many farmers practiced side selling, and the quality of the product could be better since it does not meet the standards. Some farmers failed to successfully produce any amount of yield at the end of the harvest cycle. Therefore, this research considered three rural areas of the country involved in AgroNAT contract farming. Respective regions 1, 2, and 3 are shown in Fig. 2.12.

Specifically, region 1 encompasses six islands: Ha. Kelaa, Ha. Baarah, Hdh. Nolhivaranfaru, Hdh. Nolhivaran, and Hdh. Vaikaradhoo. They are situated in the Upper North province, characterized by consistently hot and humid weather conditions throughout the year, typically receiving an annual rainfall of approximately 193.14 mm.

These islands are home to a total of 165 contract farmers, cultivating a combined land area of 689544 sq. ft (square feet), where 1 sq. ft ~ 0.0929 square meters and 1 hectare ~ 107639 sq. ft. [11].

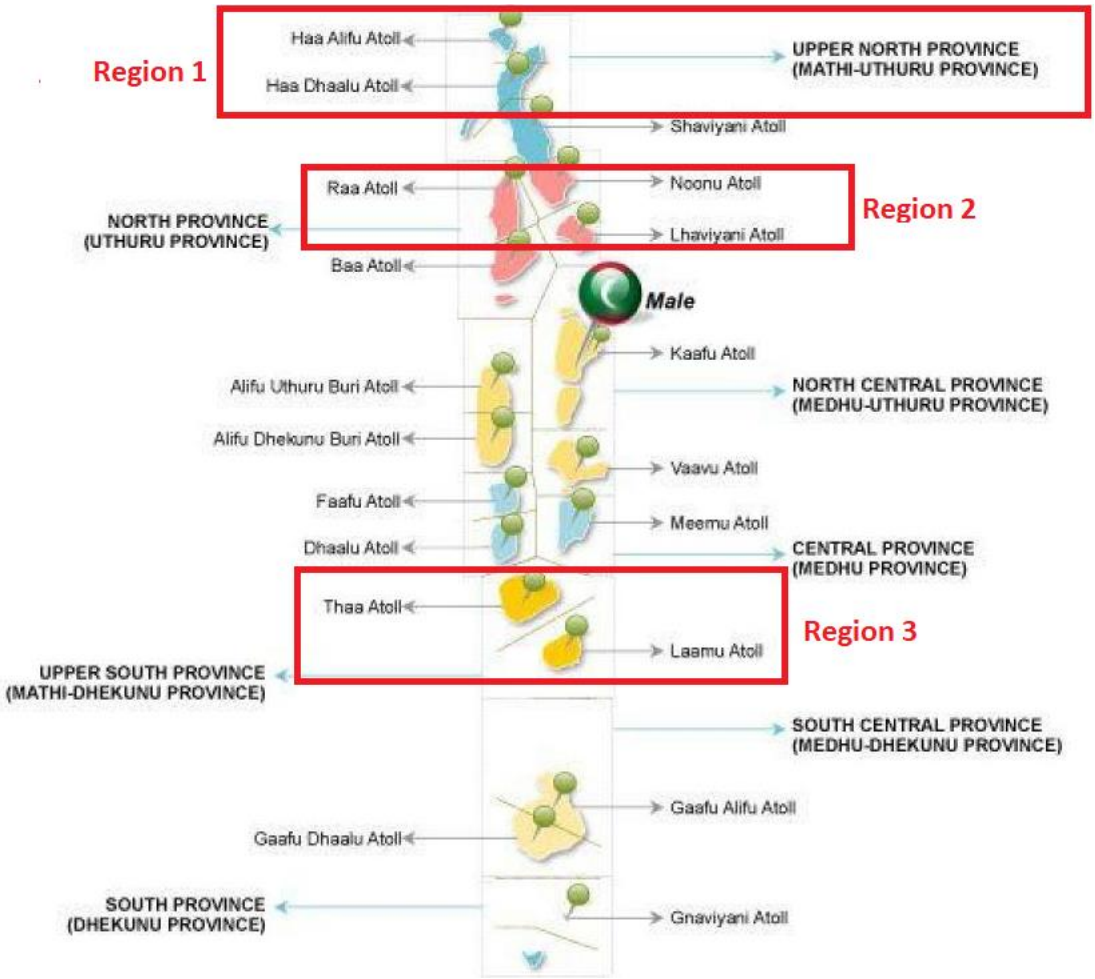

Fig. 2.12. Representation of three agricultural regions explored in this study

Source: compiled by the author based on [11]

Region 2 encompasses R. Kinolhas, N. Manadhoo, and Lh. Olhuvelifushi, where a total of 116 contract farmers cultivate a combined land area of 922456 sq. ft. L. Isdhoo, L. Kalaidhoo, L. Gan, L. Fonadhoo, and Thaa-Kandoodhoo, situated in the Upper South province, belong to region 3 where total of 200 contract farmers operate on a total land

area of 3146000 sq. ft. These farmers experience hot and humid climates with 219.67 mm of precipitation throughout the year [11].

After visiting 14 islands, data from 481 farmers were accumulated to identify the efficiency of farms in crop production from explored regions where AgroNAT implemented a contract farming model in 2021. Informal interviews and focused group discussions were carried out with more than 1200 farmers who were directly intervened to understand the nature of their farming and assess the agriculture situation in the Maldives. It should be noted that further outcomes illustrated in Tables 2.1–2.4 are based on the number of farmers interviewed, including farmers registered under AgroNAT as contract farmers as well as family farmers who don't cooperate with AgroNAT. In addition to direct observation and intervention, data were collected through the official materials from the AgroNAT record keeping.

The Chi-square Test for Independence proved similarities in Maldivian agricultural regions 1, 2, and 3, which made it possible to compare two hypotheses concerning two categorical variables with I and J groups of values, respectively. In particular, the null hypothesis H_0 supposes that the variations between the observed and expected values are random and that the examined categorical variables are unrelated. Alternative hypothesis H_α suggests significant variations between the observed and expected values, implying the existence of some relationship between the considered categorical variables.

Theoretically, the analyzed data incorporates two tables containing observed O_{ij} and expected E_{ij} frequency associated with a value i of the first variable and a value j of the second one, i=1...I, j=1...J. The calculated Pearson's Chi-square value X^2 can be found through the formula

$$X^2 = \sum_{i=1...I\ j=1...J} ((O_{ij} - E_{ij})^2 / E_{ij}). \quad (2.1)$$

To carry out the Chi-square Test for Independence, we need a critical Chi-square value $X^2(\alpha, df)$, where the parameter α denotes the significance level, and the coefficient df = (I-1)·(J-1) is a number of degrees of freedom. The true inequality

$$X^2 \leq X^2(\alpha, df) \quad (2.2)$$

rejects hypothesis H_α and confirms hypothesis H_0. It proves that the categorical variables are independent, and groups of their values don't influence each other. In contrast, the true inequality

$$X^2 > X^2(\alpha, df) \quad (2.3)$$

rejects hypothesis H_0 and confirms hypothesis H_α. It means that the categorical variables are essentially related, and groups of their values significantly impact one another.

According to Fig. 2.9, the use of natural resources was analyzed in the first place. Indeed, access to arable land for farming activities is one of the main challenges the farming population faces in developing countries. Considering the significant agricultural contribution to eradicating poverty and supporting communities' staple income, we should consider land access as an important factor in strengthening farming communities. The fact that the Maldives has a small amount of agricultural land available among all the South Asian countries poses a significant challenge to AgroNAT efforts in enhancing the productivity of family farming communities. Besides, the local councils are also using the open land area of the rural islands for living purposes or other activities, such as tourism and fishing, neglecting the importance of agriculture.

Through direct intervention with the farming population of three regions, which includes both contract and non-contract farmers, it is evident that all the farmers face land constraints that restrict them from carrying out farming activities which might help them gain economic benefit. Most farmers raised their concern over interest in joining the AgroNAT contract farming model. Yet, due to the unavailability of land space, they cannot adequately participate in offered contract programs. Namely, Table 2.1 accumulates initial data on land accessibility in regions 1, 2, and 3. The calculated results made it possible to find two similarities.

Firstly, the performed Chi-square Test for Independence (2.1)–(2.3) with I=2, J=2, and conventional $\alpha=0.05$, resulted in true inequality.

$$0.025 = X^2 \leq X^2(\alpha, df) = 3.841, \quad (2.4)$$

which showed a strong resemblance between regions 1 and 2 by indicators of "No arable land" and "Land tenure insecurity."

Secondly, the performed Chi-square Test for Independence (2.1)–(2.3) with I=2, J=2, and conventional α=0.05, resulted in true inequality

$$0.544 = X^2 \leq X^2(\alpha, df) = 3.841, \quad (2.5)$$

which revealed a strong resemblance between regions 2 and 3 by indicators of "Started farming" and "No arable land."

Table 2.1

Data on land accessibility in regional agriculture in the Maldives

Status of farmers	Number of farmers		
	Region 1	Region 2	Region 3
Started farming	90	150	219
No arable land	100	112	184
Land tenure insecurity	115	125	105

Source: compiled by the author according to [9]

These outcomes show absence of arable lands and land tenure difficulty in region 1 and region 2. The local government authority's newly implemented Land Use Plan (LUP) requires the island council to develop a plan to distribute lands for economic activities. As per the new guideline, farmers can only farm in areas allocated under LUP. The delay in making this plan has restricted farmers from cultivating the previously owned farmlands.

Moreover, based on political interests, some local government bodies and island atoll council decreased the land leased period to 6 months, narrowing down farming communities to carry out long-term farming activities. Most island councils in regions 1 and 2 still need to develop these LUP. As a result, many farmers have shown interest in the AgroNAT contract farming program but cannot start farming as the council has yet to allocate farmlands. For some farmers who have been farming for years, their farmlands were taken by the Commission for tourism development, and land areas with giant trees

such as coconut palms were assigned instead. Since farmers are supposed to pay the council for each palm tree, people cut them down to clear the land for farming purposes. The subsistence farmers with no stable income have no means of paying for this and no means of clearing thick vegetation as they need more tools and equipment to do that work. Thus, although AgroNAT has registered and provided farmers with input, technical skills, and knowledge, farmers need help doing farming activities due to the described challenges.

Consistent with Fig. 2.9, the quantity and quality of the labor force in the Maldivian agriculture matter. That is why gender disparity observed in regional farming communities and recruitment of young farmers were explored in the second place.

According to the FAO data [99], 54% of the registered farmers in the Maldives are rural women restricted to subsistence farming without proper equipment and knowledge. Small family farmers and their way of life strongly impact the environment, which is greatly determined by how they interact with the surrounding nature and its resources. Frequent mismanagement results in the loss of natural resources and farmers' health. Due to their lack of farming knowledge and social belief, in many instances women are relegated to labor intensive activities such as weeding, planting, and harvesting, while men typically assume decision-making responsibilities [121], [132].

As shown in Table 2.2, there is a difference in the number of women farmers across three regions, where region 3 has the largest share of females who are in charge of their family farms.

Table 2.2

Data on gender disparity in regional agriculture

Head of the family farm	Region 1	Region 2	Region 3
Males	95	90	147
Females	7	8	112

Source: compiled by the author according to [9]

The performed Chi-square Test for Independence (2.1)–(2.3) with I=2, J=2, and conventional α=0.05, led to true inequality

$$0.122 = X^2 \leq X^2(\alpha, df) = 3.841, \quad (2.6)$$

which revealed an equal representation of male and female head farmers in regions 1 and 2. Unlike region 3, regions 1 and 2 depend on farming as their main source of income. Men in region 3 can earn a living by fishing, and women can support their families by selling dried fish and other fish products.

Since the beginning, regions 1 and 2 are not famous for fishing. Most of their population, uninvolved in government and private sectors, depends on farming activities. These islands also experience internal immigration from remote islands, where women must support their families and carry out farming activities. They also sell locally grown vegetables and fruit in homemade street stands [9].

Gender disparity is a global issue that is more common in rural farming communities. Female farmers play a significant role in agricultural production. According to FAO, 43% of this work is performed by women, and most are involved in subsistence farming with less access to productive resources, such as certified seeds, crop-specific fertilizers, chemicals, and agricultural finance. With a lack of financial knowledge and social beliefs, women face many barriers and restrictions in investing in economic activities due to their obligation of complex household chores and pursuing multiple livelihood strategies [132], [135].

Numerous reports also state that women in farming are categorized as simple “helpers” rather than producers, which prevents them from owning and controlling the necessary resources for agricultural production. Similarly, a lack of courage and social norms impedes women’s participation in farm business activities limiting their essential agricultural role [145].

Recent research shows that contract farming can reduce the gender gap by increasing the net economic benefits for females and males and leveraging differences

between women and men in farming activities [163]. The AgroNAT contract farming model is a means to address the gender disparity among the family farming communities by addressing the challenges faced by these farmers. One major constraint that family farmers faced was limited access to land and its ownership. In most cases, the land is in the name of the men of the family, which hinders females' ability to partake in contractual agreements as it requires contract farmers to be owners of their farmland. Moreover, though the Maldivian population has a 99% literacy level, the level of financial knowledge is comparatively lower among female farmers, which prevents them from accessing financial services, coupled with their lack of confidence in entering into such agreements.

Regarding farming population age, statistics reveal that 80% of the Maldivian farmers are over 40. All these farmers have been farming from the knowledge and skills passed by the elders. These farmers practice conventional farming methods, exploiting the soil nutrients and the incorrect application of fertilizers [135]. Initial data on farming population age for regions 1, 2, and 3 are collected in Table 2.3.

Table 2.3

Data on farming population age in regional agriculture

Head of the family farm	Region 1	Region 2	Region 3
Below 40 years of age	2	5	70
Above 40 years of age	100	93	189

Source: compiled by the author based on [9]

The performed Chi-square Test for Independence (2.1)–(2.3) with I=2, J=2, and conventional α=0.05, led to true inequality

$$1.460 = X^2 \leq X^2(\alpha, df) = 3.841, \quad (2.7)$$

which confirmed a strong resemblance between regions 1 and 2 by farming population age. Studies show that farming activities act as a way of supporting the livelihood of older

people, primarily among low- and middle-income countries [163]. The Maldives belongs to South Asian countries where most of the rural population is above 60 years old, and the average life expectancy is 79.6. So, the most active population is 40-60 which is true for regions 1 and 2.

Given the fact that more than 50% of the graduates of the island inhabitants move out to nearby resorts for jobs and to the capital city to be employed, like in all other developing nations, the Maldivian agriculture is considered a low level of work and, hence, the young working people show no interest in joining farming activities [100].

Furthermore, fragmented agriculture, lack of support, and no guarantee of sustainable income from the sector drive the young away from farming activities. Most farmers in regions 1 and 2 need access to running water and electricity and still use traditional farming methods. Since the beginning, everyone in the Maldives has had access to primary education. Hence, 90% of the farming population can read and write and thus use fishing and farming activities as income. The young people with access to secondary education immigrate to bigger islands or nearby resorts in search of employment and leave the old, aged population to do menial earning activities.

The research reveals a significantly different situation in region 3 with more active farmers above 40. Besides, there are 27% of the farmers under 40. This is true because compared to regions 1 and 2, region 3 is more developed, with economic activities, such as tourism, grocery shops, market outlets, and the private sector, targeted by commercial commodity farmers.

In addition to this, there are tourist resorts with easy transport access allowing the farmers to sell their produce to earn an income. The availability of resort markets and local outlets guarantees that farmers get paid for their produce [134]. Not to mention that non-profit organizations such as UNDP and IFAD also intervene with the local farming communities of region 3 as there is more arable land given expanding farming activities. Hence, these donor agencies also invest in building technology-based farming methods

such as auto pots, fertigation, hydroponics, and greenhouses which attract the young generation to participate in farming activities [116].

Finally, according to Fig. 2.9, family farmers in the Maldives need consulting agricultural support and assistance. Knowledge and skills are crucial factors that play a massive role in improving farming activities toward sustainability. The result of farmers' interviews gave solid evidence that Maldivian family farmers lack good agricultural extension services, especially on the urgent topics clarified in Table 2.4.

Table 2.4

Data on critical issues in regional agriculture in the Maldives

Number of farmers struggling	Region 1	Region 2	Region 3
Supply of inputs	105	160	99
Accessibility to markets	97	103	189
Accessibility to finance	98	112	190
Climatic instability	5	12	30

Source: compiled by the author according to [9]

The performed Chi-square Test for Independence (2.1)–(2.3) with I=2, J=3, and conventional $\alpha=0.05$ resulted in true inequality

$$0.231 = X^2 \leq X^2(\alpha, df) = 5.991. \quad (2.8)$$

This shows that all three regions are equally interested in accessing markets and finance. Family and subsistence farmers need the means to sell their production, lack infrastructure and service provisions, and therefore struggle to shift from subsistence to more productive ways of farming. Unsurprisingly, these challenges prevent small farmers from diversifying and scaling up their farm activities.

AgroNAT corporation provides logistical support to farmers to deliver their produce to market points regardless of location to facilitate market access. Hence, the performed

calculations persuade that all three regions have equal market access. Due to the islands' geographical dispersion, some islands have an advantage over the other islands by being close to the main market points. The islands of regions 1 and 2 are close to the primary market. However, the company also has built cold storage facilities to keep the perishable goods at the right temperature until they are sold off or transported to the nearest market point. To assure the farmers and motivate them to continue the company's farming activities, AgroNAT buys 100% of the farmer's produce. This encourages the farmers to produce higher yields.

Access to credit or finance is another crucial factor affecting the success of family farming. To continue their activities, farmers need access to credit or finance to buy quality seeds, inputs, and agricultural tools and equipment to enhance production. AgroNAT corporation also supports and assists farmers who want to scale up their businesses by taking small loans through small entrepreneurship loan schemes and other financial support to women from the Maldivian government to strengthen their economic activities. The credit loan amount is deducted (2%) from each of their harvests which they sell to AgroNAT, further assuring the farmers that they are at no risk. In addition, farmers must pay this loan credit amount within two years [14]. In some cases, farmers working under contract farming agreements tend to abuse the options of credits and supply of inputs. The contract farming model of AgroNAT reduces this by buying all the products from the farmers even though they cannot meet the required amount.

In addition, the offered farmers' credit loan is free from interest. Farmers are allowed to extend their loan period in case of abrupt natural disasters and other climatic causes which result in the loss of their crops and investments. This is a massive advantage to the family farming communities living far away from market points, who had no agricultural equipment, inputs, or infrastructure and could only produce to meet their daily nutrient requirement.

It's worth mentioning that farmers in region 3 demonstrate more vital financial skills and knowledge than farmers in regions 1 and 2. One thing that restricts the farmers

from accessing available agricultural financing options is lengthy administrative procedures which scare the small family farmers as they are poor subsistent farmers with nothing besides the land they own. Poor financial skills prevent them from making the best use of economic opportunities. Similarly, the lengthy, complicated administrative procedures prevent farmers from fulfilling these opportunities.

Overall, the performed Chi-square Test for Independence (2.1)–(2.3) with I=4, J=2, and conventional $\alpha=0.05$, resulted in true inequality

$$5.775 = X^2 \leq X^2(\alpha, df) = 7.815, \tag{2.9}$$

which showed a strong resemblance between regions 1 and 2 by all agricultural issues outlined in Table 2.4.

It is observed that most farmers need more knowledge and skills to work with technology-integrated farming methods. The farmers need more capacity to kick start with the new technologies to meet production targets by introducing new crops.

On the upside, under a contractual agreement, AgroNAT supplies inputs, including chemicals, fertilizers, equipment, and tools, to perform farming activities. The company provides farmers with training programs on using fertilizers and chemicals to sow, cultivate, harvest, and store crops. Crops are monitored for their quality by the selected employees of the company who work along with the farmers as coordinators or extension officers. One of the prerequisites of building a farming community is equipping the farmers with skills and knowledge. Furthermore, to support the farmers with the required input supply, farmers are given quality seeds free of cost and inputs under a 20% discount compared to the market average level.

On the downside, AgroNAT corporation provides farmers with input on a contractual basis with their farmlands. However, intervening with the farmers showed that most are farming in farmlands without legal documents. Some farmers farm in lands where there are no human settlements. This restricts the potential family farmers from accessing inputs. In addition, all the agricultural inputs are imported and available from the primary market, which can only be reached through sea transport. Farmers are not

financially strong enough to buy these inputs from the capital city, for which they also have to pay transport costs. Moreover, farmers need to be more confident in investing in information for the risk of being unable to cover the price due to low productivity.

The calculation confirms that the unpredictable weather and adverse climatic conditions negatively affect the Maldivian farming communities in all three regions. In dry conditions, farms cannot cultivate their farmlands as the farmers depend on rainwater. Now and then huge waves wash away the whole field close to the shoreline. Besides, the thin groundwater layer is depleted with excessive water use. Thus, all the farmers in the Maldives experience unpredictable rain, strong wind, and high waves. However, region 3 is more affected by these as it has more farmers and larger farmlands than regions 1 and 2. One thing observed in regions 1 and 2 is the high waves that pass the islands from one end to another, leaving the well and groundwater saline where farmers cannot collect and store rainwater.

Overall, region 1 has more access to arable farmland, finance and markets to scale up farming activities to compensate for these issues. However, region 1 has the highest share of old-aged people working as family farmers. This reflects the importance of recruiting the young to utilize technology-integrated farming methods to increase agricultural outputs. At the same time, region 1 shows the worst gender disparity exacerbated by no access to running water and electricity and sharp land tenure insecurity.

By and large, region 2 strongly resembles region 1, including high gender disparity and aged population. Unlike regions 1 and 3, most farmers from region 2 are challenged with the unavailability of agricultural inputs to carry out farming activities. Region 2 demonstrated relatively the same access to markets and finance as regions 1 and 3.

Region 3 has enormous potential for scaling up the family farming community owing to the most significant number of contract farmers. Compared to regions 1 and 2, there is lower gender disparity among the farmers, given a more balanced representation of female and male heads of farms. Also, unlike regions 1 and 2, region 3 has a larger share of the young population involved in farming. Above all, region 3 has the largest

farmlands compared to region 2 and 3, but it does not help increase production. However, farmers in region 3 are more affected by climatic issues, which are partly compensated by better supplies of inputs necessary for diversifying regional crops and moving towards producing value-added products.

All in all, the contract farming model implemented by AgroNAT benefits the local farming communities in several ways. Through effective management, contract farming can coordinate and promote production and marketing in agriculture. That is, through the contractual agreement, family farmers are given support in prime farming inputs such as seeds and fertilizers and support on how to address plant pests and diseases. Farmers are also assisted with technical expertise in cultivating their farmlands and harvesting, along with free training and extension. In addition, the contractual agreement ensures that farmers are given quality input, maintaining higher production. Compared to non-contractual farmers, those ones who work under contract farming have better access to inputs than small farmers who don't collaborate with AgroNAT.

The AgroNAT contract farming model uplifts subsistence farming, providing farmers with credit-based loans and technical support. Under contract farming, small-scale farmers are given all the required materials to start farming under credit schemes. Unlike bank loans, credit schemes under contract farming provide leniency regarding interest and payment return methods. The latter encourages small-scale farmers to move forward under contract farming. Contracts require a certain percentage of investment that 90% of the subsistence farming communities do not have. Hence, contract farming eases the burden of the farmers in accessing credit facilities.

Thus, contract farming is an answer to the problems faced by the small family communities of developing nations, where most farmers are poor and have no access to advanced agricultural technology. This approach will assist farmers in producing competitive agricultural products to meet the market's demands, such as quality and quantity [163].

Usually, small farmers are reluctant to adopt new technologies since they have no finance and fear being unable to pay back the investment due to a lack of market accessibility and relevant information. Farmers under contract farming are assured that their products will be paid based on the agreed price. Especially the contract farmers under AgroNAT are assured that regardless of how much they produce, all their products will be bought and paid back by the company, ensuring 100% of their investment will be covered and that there is no risk in adopting technology-integrated farming methods.

AgroNAT contract farmers are also advantageous compared to non-contract farmers, as those working under the contracts are unaffected by market price volatility. Regardless of the market price fluctuation, they can initially pay the fixed price agreed upon. In addition, small family farmers learn improved farming methods and ways of carrying out farming activities to meet the new market demands. This way, farmers practicing conventional farming and using fertilizers and chemicals based on experience will learn advanced agricultural practices and measures through field activities following a strict timetable imposed by the extension officers under contract farming.

To sum up, all the challenges the family farming communities in regions 1, 2, and 3 face prove that small-scale farmers can benefit from their activities when involved in contract farming. However, before moving forward, it is essential to consider how contract farming can address these challenges based on the research results presented below.

Conclusions to Chapter 2

1. Agricultural sector in the Maldives with a share of around 5% is a weak contributor to the national GDP dominated by the tourism industry. Farming is mostly located in island communities which are dispersed, undeveloped and encompass 60% of the population. Official employment in agriculture of 10% is low since people in rural areas run subsistent farming to ensure their livelihood. Over the last 15 years population in the Maldives doubled so that the increased food demand exacerbated the national

dependency on food imports. Recent hazardous natural disasters and global shocks like Covid-19 pandemic restrictions have revealed crucial food and nutrition insecurity which have led to launching government programs to support farmers on the way to sustainable agriculture in the Maldives. They mean protecting small family farmers who are vulnerable to market and climatic risks as 90% poverty-stricken people inhabit remote rural areas and are unexperienced in planning and organizing sustainable farming to earn a living and grow quality agricultural produce.

2. The core challenges which the Maldivian farmers have to address are about limited amount of land suitable and utilized for agricultural activities as well as shortage of water resources necessary to grow quality harvests of local vegetables, fruits, and staple crops. Besides, unawareness of advanced technologies prevents farmers from moving away from labor-intensive methods to more efficient farming activities which can bring tangible economic benefits provided through recruitment and retention of family farmers, especially underrated females and active youth uninvolved in agriculture. It made it possible to conclude that improvements in farm management should be promoted through a complex approach in economic, social and environmental dimensions implemented via rational use of natural resources, agricultural consulting services, and labor force enhancement as three pillars and driving forces to push building sustainable agriculture in the Maldives.

3. Farming in the Maldives is carried out for two purposes such as obtaining required food and nutrition security as well as earning profits. PESTLE analysis provides a contemporary tool for clarifying farming surroundings and highlighting macro factors that may profoundly affect agricultural activities regarding beneficial opportunities and challenging threats. The determined and identified Political, Economic, Social, Technological, Legal, and Environmental factors are invaluable in strategic decision-making utilized in farm management to track and assess the influential changes on the way to long-term success and sustainability so that small family farmers can forecast and

compare different agribusiness scenarios, align with potential risks, and adjust to the forthcoming.

4. The PESTLE analysis applied to the Maldivian agriculture revealed an impact of the political factor through the unimplemented National Strategic Farming Plan, reduced taxation of farm-related imported goods, fragmented Land Act, decentralized market access and transport system, undeveloped Farm Safety Net. The most influential components of the economic factor were about fluctuating inflation, chronic state budget deficit, inaccessible agricultural credits, high unemployment rate. The major aspects of the social factor which affect farming in the Maldives are presented by aging farm operators, gender imparity, as well as poor education on agriculture and rural development. Lack of technical knowledge and IT skills, and also resistance to investing in new technologies display an impact of the technological factor on farming in the Maldives. The legal factor appeared to manifest its influence through undeveloped laws of land access and ill-conceived procedures of agricultural insurance, not to mention absent immigration regulations and missing quality control over imported food. The environmental factor shows its braking effect owing to barren soil, scarcity of groundwater, natural disasters, heavy rainfalls, high tidal waves which essentially hinder progress in the Maldivian agriculture.

5. The Maldivian agriculture is divided into five regions, two of which remain inactive in AgroNAT contract farming due to unregulated land tenure. AgroNAT unites almost 500 small family farmers on 14 islands which are actively involved in agricultural production in the Maldives in order to halve imports of the major crops by the end of 2023. Therefore, AgroNAT is focused on supporting just three regions, where family farming communities are prominent and depend completely on their agricultural activities as their primary source of income, nutrients, and a way of living. Contract farming model implemented by AgroNAT benefits the local farming communities in several ways providing basic inputs such as seeds and fertilizers, technical support in addressing plant pests and diseases, harvesting crops, maintaining free training and consulting, ensuring

access to credit-based loans and protection from market price volatility when selling the grown produce. This became an answer to the Maldivian family farmers, who were highly restricted by poor productivity, unavailability of natural resources and insufficient profits to perform successful farming due to shortage of accessible investments.

6. Informal interviews and focused group discussions with 1200 family farmers in three regions which take part in AgroNat contract farming disclosed the nature of their farming and allowed to assess the agriculture situation in the Maldives. The Chi-square Test for Independence proved a strong resemblance between regions 1 and 2 by indicators of "No arable land" and "Land tenure insecurity" as well as an essential similarity between regions 2 and 3 by indicators of "Started farming" and "No arable land". Region 3 has an advantage of the largest agricultural areas. Regions 1 and 2 have the same high shares of aging farmers as well as strong gender disparity. Region 3 outruns them by the quantity of young and female farmers. Mathematical calculations confirmed that farming communities of all regions are equally interested in accessing markets and finance. At the same time, region 2 benefits from a close location to the capital of Male. Farmers of region 1 are the least concerned about climatic instability. Supply of input appeared to be the most challenging issue in region 2. All of the above should be addressed through improved management and further development of contract family farming in the Maldives.

The scientific results of Chapter 2 are published by the author in [1], [6], [7], [9].

CHAPTER 3.
IMPROVEMENTS OF FAMILY FARM MANAGEMENT FOR SUSTAINABLE DEVELOPMENT OF MALDIVIAN AGRICULTURE

3.1. Optimization of regional contract farming to reduce crop imports and address food insecurity

Over the past 50 years, worldwide strategies have been implemented to boost agricultural production and enhance the agricultural sector of all nations across the globe. Strategies agreed upon by experts and implemented by world leaders to eradicate poverty and hunger do not reduce the number of hungry people worldwide. Poverty, malnutrition, and lack of access to healthy food remain a worldwide issue. According to reports, lack of access to nutrition is a global issue with a burden of undernutrition, overweight and obesity, and micronutrition deficiencies [161].

Access to good nutrition and a healthy diet is a must for children at their growth stage to their development and growth. Till today millions of South Asian children do not have access to proper nutrition, which prevents them from growing, learning, and makes nearly impossible to survive [161]. Poverty and undernutrition are correlated, as most poor people live in rural areas and predominantly depend on farming activities. In contrast, rural households spend 20–30% less on food and more on grains [182]. Reports show that per capita caloric and protein intake has been falling in rural populations of South Asian countries leading to stunted growth and malnutrition, affecting almost half of the children under age five living in rural areas in many countries [182]. UNICEF reports state that nearly 64 million children in South Asia suffer from severe food poverty, 1 in 3 children have stunted growth, and 1 in 7 children in South Asia are wasted [125].

In South Asian countries, malnutrition starts in the womb of the mother, which is strongly connected to gender inequality, where marginalized female rural farmers depend on farming activities as a means of income, living, and as a source of food and nutrition.

According to UN reports, compared to all the South Asian countries, 50% of the Maldivian children get the recommended diet. However, malnutrition and stunted growth are prevalent among children who live in rural island communities where it isn't easy to access an adequate balanced diet due to its high cost. International organizations such as the UN, FAO, and UNICEF agree that developing and strengthening family farming communities can address world hunger, as family farms comprise over 98% of farming holdings globally [96]. A recent study on the Maldivian children's nutrient levels on four selected rural islands shows a prevalence of undernutrition based on being underweight and wasting. It showed that 10.75% of the children were malnourished, 13.5% with stunted growth, and 23.85% of children wasted [25].

UN Special Rapporteur on the right to food affirms that increased food production will not address the hunger and malnutrition issue of developing nations. Instead, global leaders must focus on developing and strengthening local farming communities to re-invest in local production. He also affirms the need to invest in enhancing these farming communities' local production by giving access to productive resources. Further, it is stressed the importance of developing countries such as the Maldives to move further away from imported food products that are processed and rich in excessive salt, sugar, and saturated fats and are often less nutritious [96].

Compared to all the region's access to healthy food and nutrient requirements, Asia is a continent where the world's largest rural population resides below the poverty line. The agricultural sector, which dominates among Asian countries, consists of mainly rural farmers who depend on farming activities that provide economic, social, and environmental balance to these communities. That is, the farming activities of the farmers diversify livelihoods, mean a viable income, and eradicate the cycle of poverty, hunger, and undernutrition [170]. Agriculture and farming activities are vital in employing a significant proportion of the population and the national GDP. In developing nations, family farmers are at the forefront of agricultural activities, cultivating crops, rearing livestock, and engaging in fisheries to meet the food demands of the region [161].

Rural farming communities in South Asian countries have to face numerous challenges such as climate instability, land degradation, water scarcity, inadequate access to modern technology, limited availability of credits and loans, insufficient market infrastructure coupled with plant pests and diseases, low productivity, and post-harvest losses. All of the above negatively impact these countries' food and nutrition security [70], [108], [138].

Food security means that, regardless of economic status, everyone should have equal access to sufficient safe and nutritious food to meet people's dietary needs for an active and healthy life [47]. According to reports, by 2050, South Asia's population will reach 5.16 billion people, which will require 20% more agricultural products to offset the increase in population's food demand [24], [186]. This means that local production of farming communities and their accessibility to healthy foods must be increased by 20% to ensure that hunger and malnutrition are properly addressed among the rural population.

The Maldives belongs to the South Asian group of countries where more than 60% of the fruits and vegetables grown by the local farmers are imported to meet the resort market demand. More than 90% of the food used for local and resort consumption is imported, showing the country's high import dependency. According to reports, with growing local consumption and the resort market demand in 2022 the government imported more than $183.3 million worth of food which is an alarming amount. Due to high fragmentation, stagnant growth, underdeveloped infrastructure, poor production, and market systems, the farmers cannot meet the local and resort demands. This leaves the country teetering at the brink of disaster. Any abrupt climate changes, war conflicts, and outbreaks of diseases affect the country as a ripple effect. Hence, total dependence on imports to ensure food and nutrition security is a wake-up call for the nation [118].

Maldivian agriculture and fisheries sector contribute only marginally to GDP sector on average 4 to 5% from 2014–2020 [122]. The rural farming communities producing fruits and vegetables need access to markets, inputs, minimal technical knowledge and assistance support. These farmers can only have one-third of the national food requirement

The Maldives faced severe malnutrition due to a decrease in the local food supply in the year 2009, and in the year 2019, the country faced a food shortage due to the lockdown of borders, further increasing the price of local fruits and vegetables.

Over the past few years, no growth has been seen in the country's agricultural sector. Hence, the country's poor investment in agriculture during the past years has not built the capacity of farmers to meet the resort market demands. Reports show that the Maldives' dependency on imports has worsened over the past 25 years, and the government debt reached 80% of GDP by the end of 2022 [119]. Along with the rising inflation rate over the past three years, the increased dependency on imported food has negatively impacted the food and nutrition security of the country [44]. The situation has further deteriorated, leading to a rise in poverty among the rural population in the Maldives because of the increase in petrol prices and their spill-over products related to transport services and hikes in food prices resulting from the Russian invasion of Ukraine [175]. COVID-19 hit hard the Maldivian nation due to the lockdown of borders, which drove 19.8% of the population to poverty.

The increase in prices of agricultural inputs, transport costs, and poor market access shrank smallholder communities' farming activities, leading to lower calorie intake per day. The population residing among the island communities has been disadvantaged since the beginning [153]. The increase in inflation, high consumer price index, and other financial risks further deteriorated the situation by cutting the agricultural production of the farming communities. Besides, there is a high inequality in government expenditures and economic activities between atolls and the capital city. Maldives' poverty percentage of the population (PPP) could have hit 19.8% of the total population in 2020 due to the COVID-19 pandemic without international organization relief aids [26]. 5.5% of the total population was poverty-stricken in 2019, which rose to 10.9% in 2020. In 2021, the poverty share accounted for 4% of the total population [26], [102]. However, this percentage is expected to worsen since the government aims to increase the GST rate from 6% to 8% in 2023 [76].

During the past years, the Maldivian farmers mostly carried out their agricultural activities in land areas without urbanization. In the past Maldivian food and nutrition security depended on horticultural crops such as maize (*Zea mays*), sorghum (*Sorghum vulgare*), finger millet (*Eleusine coracana*), and starchy crops including breadfruit (*Artocarpus altilis*), sweet potato (*Ipomoea batatas*) and taro (*Colocasia esculenta*).

However, over the past 15 years the Maldives' population doubled, and the nation observed a high degree of urbanization within the island communities and in the capital city, which decreased the availability of staple foods and starchy crops due to clearing lands for urban development. Opened international trade led to a flow of imports, boosting the country's dependency. Thus, now more than ever the country is susceptible to external shocks like natural disasters, pandemics, and military conflicts [136], [175].

Data captured in the years 2019, 2020, and 2021 are not considered in the study as they are very much varied by the sudden outbreak of COVID-19, which forced to shut down the international borders restricting the number of imports into the country.

In 2022 the |Maldives has imported more than 6000 tons of watermelon, above 2000 tons of bananas, 958 tons of pumpkins more than 900 tons of melon, 803 tons of cucumbers, over 700 tons of lettuce. As shown in Fig. 3.1, to hit the import target farmers must increase their harvests by 9 times. Chinese cabbage import is 64 tons, papaya 284 tons, and tomato 325 tons, but their grown shares are the highest compared to the other crops in Fig. 3.1.

Furthermore, the total imported quantity of crops exceeds 90%, where the local farmers can only produce 7% of it. This indicates the need for more capacity of the local farmers, given that these crops are locally grown and fit regional climatic and soil conditions. However, farmers need help since their production depends on the availability of land and labor [11].

Thus, there need to be more research studies done to understand how natural resources such as land and labor can be used in the best possible manner to increase the

output of family farmers. These resources play a massive role in farming, being the fundamental inputs enabling farmers to grow crops.

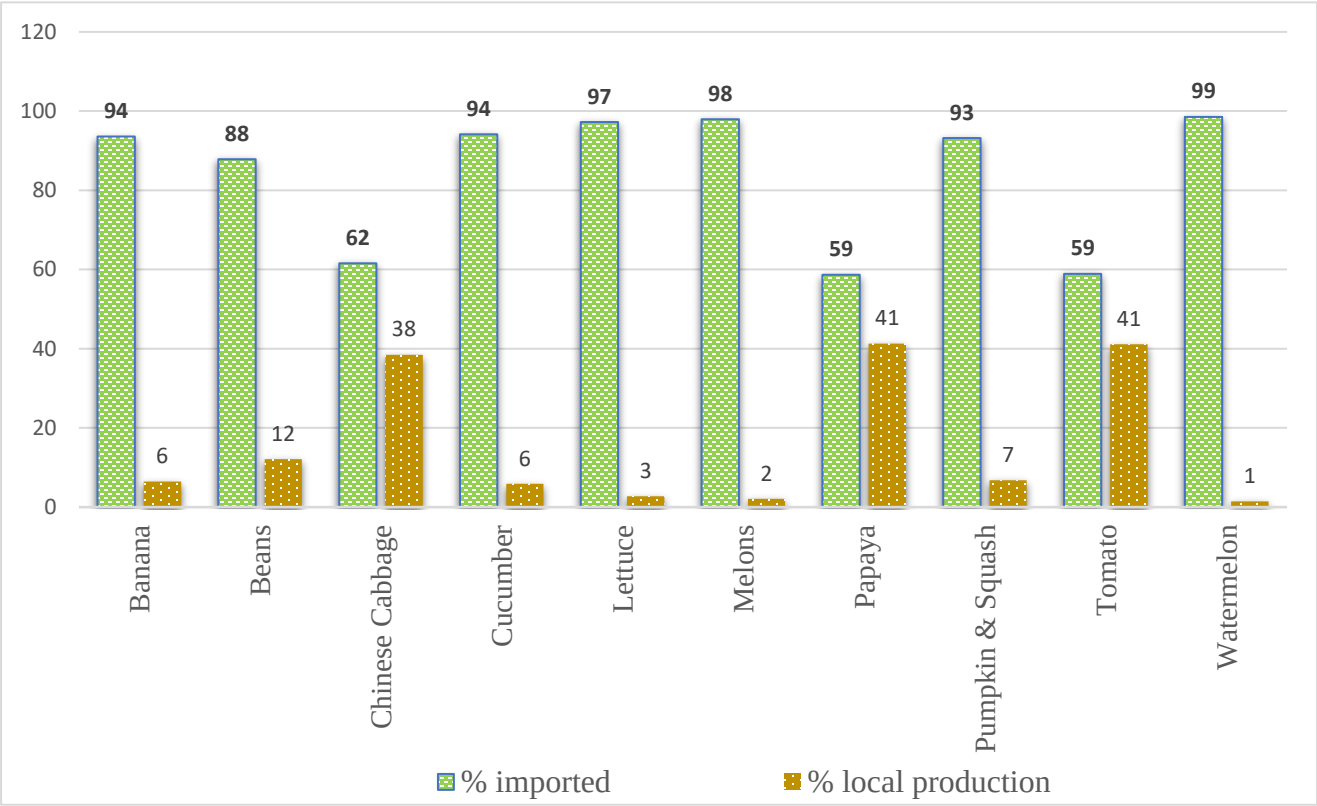

Fig. 3.1. The amount of imported and locally produced fruits and vegetables in 2022

Source: compiled by the author according to [1]

Among all these resources, the foundational resource of agriculture – land – is scarce in the Maldives. The availability and quality of land greatly determine the farmers' capacity for production. Land resources are the determinant of family farming communities which secure their livelihoods and improve well-being [127].

Carrying out farming activities, from planting, harvesting, raising livestock, and maintaining farm infrastructure, requires a solid and stable labor force. The skilled and efficient labor force ensures that farming activities are carried out and planned to achieve farm production. The lack of availability of efficient labor significantly hinders the successful operations in agriculture commonly occurring in rural areas of low-income

countries. As discussed, and mentioned in Chapter 2, the agricultural labor force of the Maldives is recorded as 8000 farmers, with almost 500 farmers registered under AgroNAT.

With no doubt, rural farming communities can only sustain their livelihood with the availability of natural resources. Natural resources encompass various elements necessary for agricultural production, such as water, soil, minerals, and biodiversity. These resources are vital for crop growth, livestock nutrition, and ecosystem health. Access and proper management of natural resources are essential for long-term agricultural productivity.

An archeological study done on understating the soil consistency and nutrient level shows that the Maldivian soil is more loose preventing it from retaining soil nutrients showing a lower amount of Nitrogen, Phosphorus, and Potassium levels in the Maldivian soil system [117].

Therefore, family farm activities must be implemented to achieve balance and should be centered around “optimum”. Managing family farms through a contract farming model must utilize various strategies and techniques to enhance agricultural productivity, reduce costs, and conserve resources. Family farm management must be organized and planned to move the farming activities toward optimization, including crop yield, equipment, and machinery [34].

To achieve crop sustainability, farmers must select suitable crop varieties, use proper cultivation techniques, modern fertilizer application procedures and farming methods such as irrigation, and adequate plant pests and diseases control. Optimization also helps farmers efficiently use available resources such as land, water, and labor via their rational allocation and utilization [183] . This will allow farmers to reduce production costs through lower input costs and diminished waste, minimizing negative environmental impact. Similarly, optimization aims to maximize productivity by reducing cost, improving efficiency, and optimizing farm activities.

According to FAO, there are five crucial steps that the governments of all developing nations must take to achieve and ensure food security. This includes providing

arable land to farming communities, giving access to water resources through irrigation, maintaining suitable farming tools and machinery to increase efficiency, providing access to quality fertilizers, and ways to address farm-related issues such as plant pests and diseases control. These five determinants will drive the community to achieve food security and enhance the economic growth of these communities, which will have a more significant positive effect on the nation's whole economy [188].

Hence based on this, it is essential to study Maldivian family farmers' production capacity and understand how their production capacity can be enhanced by utilizing the available agricultural resources to increase the farm production of certain highly imported dependent crops and how much land and labor resources are required to fulfill national goals of sustainable agriculture and food security [29]. Farming activities can be improved if the farmers can minimize manual labor and invest their time and energy in more practical and meaningful farming activities. Optimal selection and maintenance of proper farm machinery will reduce expenditure and enhance overall productivity.

As shown in Fig. 3.2, lands are unevenly distributed for growing the most demanded crops. Only 5% of the land is used to grow watermelon, whose imported amount exceeds 90% (more than 6000 tons), whereas the largest share of 42% of agricultural land is used for growing bananas. However, their imports are also over 90% that means their producers need to optimize their farming activities in the available land resource. The second largest share of land is utilized for growing pumpkin and squash, which have a longer shelf life than other crops. But these crops are susceptible to plant pests and diseases. Therefore, local farmers spend a lot of time and investment to ensure a quality product. Similarly, melon, lettuce, and watermelon crops utilize only by 5% of the agricultural land. With their import shares of over 90% they definitely require additional land to increase their production.

Looking at how labor is distributed among these crops (see Fig. 3.3), we can conclude a similar trend compared to Fig. 3.2. Fig. 3.3 shows that 5–7% of labor is used for cultivation of beans, cucumber, lettuce, melons, papaya, tomatoes, and watermelon.

On the other hand, 49% of the labor force is utilized for banana growth, with imports of up to 94% to meet the demands. Chinese cabbage and pumpkin use the lowest share of work, 4 and 3%, respectively. These results mean family farmers must utilize these resources to meet the local and resort consumption demands.

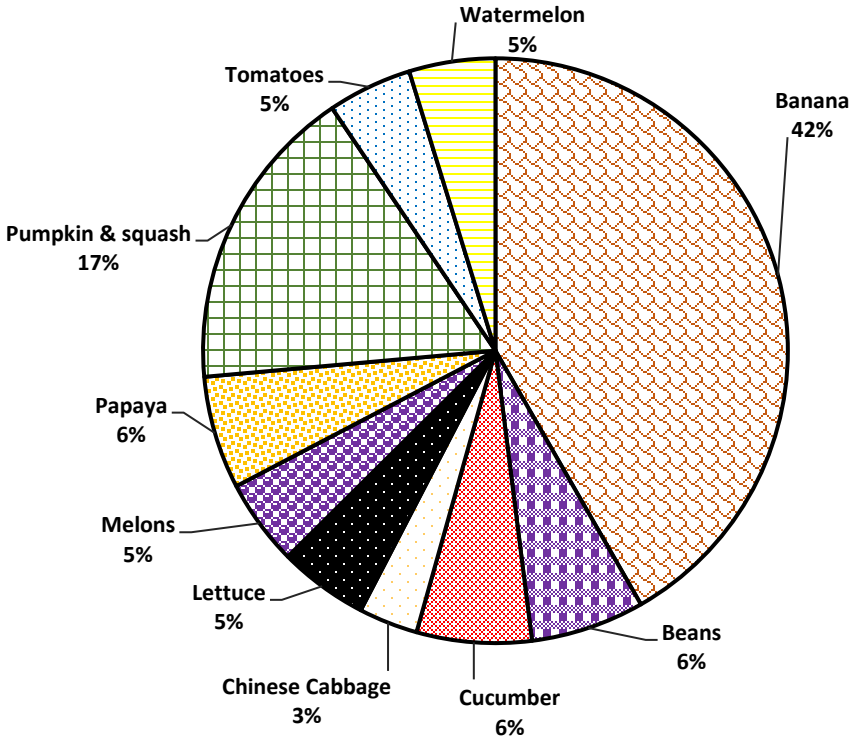

Fig. 3.2. Distribution of lands (in %) available for agricultural purposes in 2022 in the Maldives

Source: compiled by the author according to [1]

Drinks made from watermelon are popular among the locals as well as tourists as such refreshing beverages are widely served in resorts. Due to the low productivity of the local farmers, more than 90% of the required watermelons are imported from the neighboring countries. The fact that fewer farmers choose watermelon cultivation reveals the challenges faced by the farmers in growing this crop. Watermelon is a crop that requires extensive amounts of water during the fruit maturing stage. It also demands time to water the plants twice daily and pollinates flowers when it is time for the fruiting stage.

Thus, watermelon is labor extensive and requires access to water resources to produce a quality harvest. As discussed before, the Maldives is a country where 90% of the farmers depend on rainwater. During the dry season, the Maldivian farmers have no access to enough water to maintain watermelon fields, which drives watermelon production to zero. Farmers participate in off-farm activities, and the women farmers who are burdened with house chores cannot invest time in attending the watermelon fields that leads to poor amounts of watermelon harvests.

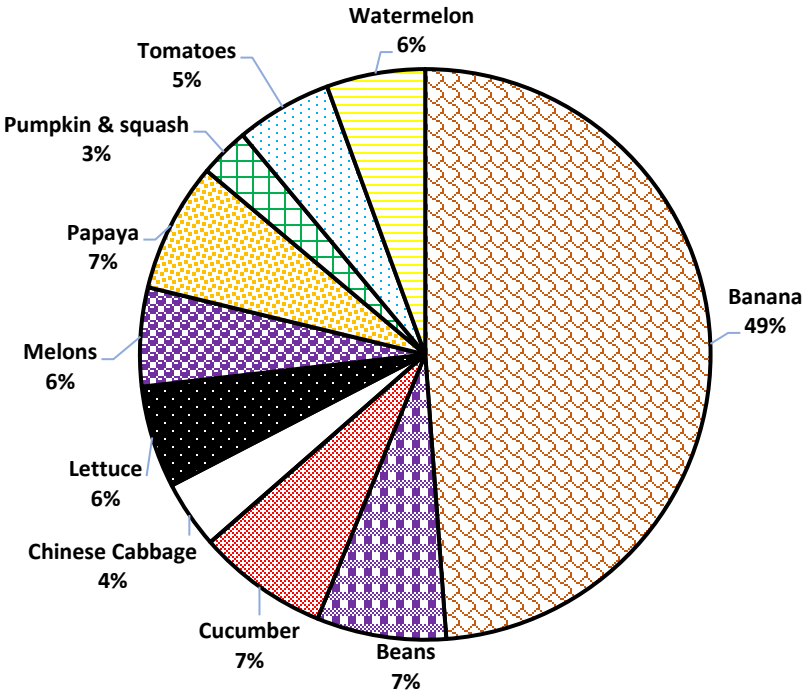

Fig. 3.3. Distribution of farmers (in %) available for the growth of the top imported crops in the Maldives

Source: compiled by the author according to [1]

Bananas are a high-cash crop that local farmers grow extensively in fields and their backyards. As shown in Fig. 3.2 and Fig. 3.3, the highest percentage of land and labor is under banana plantations, which is more than enough to cover the imports, but due to the low performance, it requires more land. Fig. 3.2 shows that almost 50% of the farmers are

banana farmers, whereas the percentage distribution of farmers who grow other crops is significantly lower. This is because banana plants can be quickly produced in backyards and fields where they can access water easily without much agricultural input. Once planted, farmers are required to attend to these crops once or twice a month for pruning, and when the banana plantation is at the harvesting stage, it can continue for 11 months at a stretch, giving farmers an advantage over the other crops.

Plant pests and diseases issues are minor for this crop. |Hence, their profit exceeds the time and money invested in this crop. Though this is why most farmers chose bananas, the country cannot produce quality products to meet the import demand. This is because the farmers' lack of investment in time and money reduces the quantity and quality of bananas produced. The flowering and fruiting stage of the banana requires protecting the fruits from bat attaches and proper handling and transporting techniques to grow quality produce. Local farmers do not invest in this, and as a result, they lose their market value and reduce the amount that these fields can produce [1].

Papaya is a tropical crop grown by all the local farmers and, like watermelon and banana, is widely used by the local population in their diet. Moreover, there is a vast resort market for this crop. Papaya is a crop like watermelon, which requires extensive water. An estimated 20–25 liters of water is needed at the growth stage, which gradually decreases when it reaches its fruiting stage. Unlike watermelon vines which lay low on the ground, papaya plants are tall and require an irrigation system with a watering hose to water these plants. Most rural farmers need access to such farming equipment, hindering the quality of their papaya produce. In addition, papaya is a highly perishable fruit susceptible to skin damage, reducing its market value. Poor pre- and post-harvest handling techniques reduce the monetary value of their products and the need for product transport options available. Also, no access to cold storage decreases their shelf life, leading to the wastage of papaya farmers' produce. Hence, most papaya farmers' produce does not reach the market point.

Crops such as Chinese cabbage and tomato imports reach approximately 60%, lower than the other discussed crops. The low production of these crops indicates that the available land area should be used more efficiently [1]. It requires other mediums, such as hydroponic and fertigation, to produce high quantity of quality yield. However, with the fragmented agriculture these farming methods are too expensive for the farming communities to invest in without guaranteeing a buyer for their product. The Maldives faces unpredictable weather conditions, so growing crops such as tomatoes, capsicum, and leafy vegetables in an open field is difficult for family farmers and requires technology-based farming methods.

Lettuce and cucumber require additional land and labor resources to meet the import demand. These two crops are in a high resort market. Unfortunately, 90% of the leafy vegetable farmers' production is lost due to uncontrollable plant pests and diseases issues which farmers cannot detect and treat at the early stage as a preventive measure [1]. One other thing that Maldivian leafy farmers faced was transport difficulty. Though farmers can produce green vegetables such as lettuce, there is no transport mechanism with conditions such as cold temperatures to keep the green vegetables fresh until they reach the market point, and hence it loses their market value. Resorts demand high-quality fresh fruits and vegetables, and hence owing to these restrictions, they prefer imported fruits and vegetables over local farmers' produce. These difficulties reduce the production of lettuce though there is the availability of land resources to these farmers.

In the Maldives, farmers grow cucumbers in the open field where it is easy to grow normal cucumbers (*Madam variety*). This variety of cucumbers retains quality and quantity compared to green or salad cucumbers (*Riches Variety*). However, the resort market and local restaurant chains demand the last one. Green or salad cucumbers have very delicate skin which gets easily damaged when touching the soil and losing its market value. Moreover, a high infestation of plant pests such as White-Breasted Waterhen, locally known as "Kanbili," which attacks cucumber plants, reduces farmers' yield since farmers can't afford to cover their open fields completely with nets or other materials.

To sum up, the available resources, such as land and labor, are not rationally managed and optimized to produce quality products to meet the country's requirements. As a result, the nation is highly dependent on imports to provide the national food and nutrition security. Hence, it makes sense to redistribute and reallocate resources to achieve production optimization.

According to AgroNAT reports, it has acquired 4758000 sq. ft of agricultural land by the end of 2021. 62.5% of these areas are utilized for growing cassava and sweet potatoes. Besides, the AgroNAT family farmers carry intercropping such as growing annual chilies, curry leaves, together with perennial coconut trees, areca nuts, breadfruits, and guava trees in one plot. These small family farmers operate on 5382–21528 sq. ft or 0.05–0.2 hectares of land areas, as depicted in Table 1.2. Nevertheless, annual report of AgroNAT shows that it is operating at a deficit where the company has failed in generating revenue or earn any profit [14].

AgroNAT registered contract farmers from the three regions are compared based on their choice of production of heavily imported crops. It shows that region 3 farmers grow mostly crops such as bananas, watermelon, brinjal, and pumpkin. In region 2, the farmers mostly grow cucumbers, butternuts, and pumpkins. In regions 2 and 3, farmers also grow sponge gourds. Based on the production quantities, harvests in region 3 are higher compared to regions 1 and 2. Region 2 has recorded the lowest production. According to the National Bureau of Statistics, islands under region 3 produced 50% more crops, such as watermelon, banana, cucumber, and pumpkin, than regions 2 and 1 [11].

Optimization of crops is conducted for the 9 crops, including fruits and vegetables that the locals and the tourist resorts most use. Almost all the Maldivian farmers across different island communities produce these 9 crops as it can be easily grown in a tropical climatic country like the Maldives. These vegetables and fruits are cultivated on 37.5% of agricultural lands acquired by the AgroNAT contract farming. The list of these crops includes:

1. pumpkin (*Cucurbita pepo L.*),

2. banana (*Musa paradisiaca L.*),
3. watermelon (*Citrullus lanatus L.*),
4. butternut (*Cucurbita moschata L.*),
5. cucumber (*Cucumis sativus L.*),
6. papaya (*Carica papaya L.*),
7. melon (*Cucumis melo L.*),
8. brinjal (*Solanum melongena L.*),
9. sponge gourd (*Luffa aegyptiaca L.*).

Based on the Maldivian climatic conditions, all the crops can be harvested two times per year except for one harvest of banana and papaya. The model considers the agricultural lands, a few input costs, and yield coefficients. The sought land areas X_{ij} for optimizing production are associated with region i and crop j

$$X_{ij}\ (X_{ij} \geq 0),\ i=1...3,\ j=1...9. \tag{3.1}$$

With a total agricultural land allocation of A_i in region i available for redistribution, we are confronted with a series of inequalities to address:

$$\sum_{j=1...9} X_{ij} \leq A_i,\ i=1...3. \tag{3.2}$$

The equations presented include parameters B_i, which establish the financial constraints on production expenses, and parameters C_{ij} representing the annual unit input cost for crop j in region i:

$$\sum_{j=1...9} C_{ij} \cdot X_{ij} \leq B_i,\ i=1...3. \tag{3.3}$$

The model takes into account both the maximum (D_j) and minimum (E_j) output quantities for each crop j that with an annual yield of F_{ij} in region i stipulate the formulation of the following set of inequalities:

$$\sum_{i=1...3} F_{ij} \cdot X_{ij} \leq D_j,\ j=1\ldots9, \tag{3.4}$$

$$\sum_{i=1\ldots3} F_{ij} \cdot X_{ij} \geq E_j,\ j=1...9. \tag{3.5}$$

Coefficients G_j represents the purchase price for crop j, which AgroNAT pays to farmers, and H_j is the wholesale price for crop j set by AgroNAT. The first model criterion calculates the total income earned by farmers from optimal harvests, namely:

$$\sum_{j=1...9} \sum_{i=1...3} G_j \cdot F_{ij} \cdot X_{ij} \rightarrow \max \quad (3.6)$$

The second model criterion calculates the total AgroNAT profit such as:

$$\sum_{j=1...9} \sum_{i=1...3} ((H_j - G_j) \cdot F_{ij} - C_{ij}) \cdot X_{ij} \rightarrow \max \quad (3.7)$$

Table 3.1 below gives the model values of A_i and B_i for each region. These areas are available for redistribution as farmers are eager to scale up their agricultural activities. It also illustrates a discrepancy in financing agriculture by farming regions for reasons such as soil conditions, access to water resources, and control of plant pests and diseases. As shown in Table 3.1, region 1 invests the highest input cost as it has less fertile soil, forcing farmers to apply more fertilizers into the ground before cultivating their crops.

Table 3.1

The model values of A_i and B_i by regions

Parameter	Region 1	Region 2	Region 3
A_i, sq. ft	412643	777925	446556
B_i, MVR	1379422	1344018	696619

Source: compiled by the author according to [11]

Values of model parameters about yields and inputs are accumulated in Table 3.2. It depicts that farmers in region 1 invest a high input cost in growing “Riches” or green cucumbers by practicing unique technology of using “grow bags,” which require coco peat which is more expensive than cow dung used by other farmers who grow cucumbers in soil. This approach of growing cucumbers in controlled mediums ensures both higher profits and a 70% higher quality yield than traditional farming.

The zero value of F_{ij} in Table 3.2 shows that region 2 is unsuccessful in growing melon, brinjal, and sponge gourd. Sponge gourd is a vegetable with 706.8 kg of produce at an area of 3000 sq. ft and can be harvested 11 times from one harvesting cycle. Region 2 farmers, compared to other region farmers, are faced with issues such as plant pests and diseases that damage crops such as brinjals. This is because in region 2 farmers carry out farm activities in open fields with densely grown bushy plants and trees surrounding their farming areas, making it difficult for the farmers to control these plant pests and diseases issues. In addition, region 2 farmers are challenged in growing melon as growing this crop in open fields produces poor quality reduced size fruit due to the lack of soil nutrients.

Table 3.2

The values of parameters C_{ij} and F_{ij} for model crops

Crop	C_{ij}, MVR/sq. ft			F_{ij}, kg/sq. ft		
	Region 1	Region 2	Region 3	Region 1	Region 2	Region 3
1	0,96	0,96	0,97	0,03	0,03	0,24
2	2,07	2,07	2,07	0,09	0,02	0,08
3	1,12	1,13	1,13	0,07	0,08	0,25
4	0,90	0,89	0,89	0,03	0,02	0,02
5	11,84	1,40	1,39	0,09	0,02	0,06
6	1,17	1,14	1,15	0,07	0,01	0,04
7	3,36	3,11	2,94	1,30	0,00	0,05
8	2,93	2,91	2,96	1,05	0,00	0,09
9	2,29	0,00	1,98	7,80	0,00	1,53

Source: compiled by the author according to [11]

Table 3.3 assembles minimal and maximal quantities of crop production. Upper limits amounted to 28%, 25%, 9%, 26%, 24%, 9%, 14%, 9%, and 28% of the respective imports. Lower bounds supposed obligatory double increasing of produce for bananas, watermelons, butternuts, and melons. The found harvest of pumpkin, cucumber, papaya, brinjal, and sponge gourd must be not less than the current ones. Table 3.3 also shows the

buying and wholesale prices of the crops. The most expensive ones are melon, banana, brinjal.

After calculations performed with the tool Solver built in the spreadsheet MS Excel, the offered optimization model (3.1)–(3.7) put forth two optimal plans, as given in Table 3.4 and Table 3.5, which provide maximal farmers' income and maximal AgroNAT's profit. The third initial plan was utilized as a reference point so as to compare a real land distribution to the calculated options.

Table 3.3

The values of parameters D_j, E_j, G_j and H_j for model crops

Crop	D_j, kg	E_j, kg	G_j, MVR/kg	H_j, MVR/kg
1	125000	13334	8	13
2	568769	36452	18	27
3	453091	59248	10	16
4	120000	6840	15	22
5	234000	17196	10	16
6	230000	2311	8	16
7	152000	11104	30	43
8	43000	2490	18	27
9	31106	31106	9	14

Source: compiled by the author according to [11]

Table 3.4 which accumulates data on improving land management and recommends shrinking crop variety across different regions. As per the Table 3.4 region 1 should assign 75% of its agricultural land to banana, 13% to cucumber, 9% to papaya, 2% to melon, and 1% to snake gourd. Likewise, region 2 ought to prioritize the cultivation of butternut and cucumber, dedicating 38% and 62% of its agricultural land to these crops, respectively. Region 3 should give precedence to pumpkin (12%), banana (24%), watermelon (54%), cucumber (4%), and brinjal (6%). Furthermore, only region 1 is urged to produce papaya, melon, and snake gourd, whereas region 2 must focus on 100% butternut cultivation.

Pumpkin, watermelon, and brinjal should be exclusively grown in region 3. Additionally, the distribution of banana production is proposed to be split with 75% in region 1 and 25% in region 3, while cucumber production is proven to benefit from distribution as 10% in region 1, 87% in region 2, and 3% in region 3. This production plan is anticipated to double the overall yields of banana, watermelon, butternut, and melon compared to the current quantities grown in regions 1, 2, and 3 as specified in plan 3 [11].

Table 3.4

Model production outcomes

	Indicator	Crop								
		1	2	3	4	5	6	7	8	9
Plan 1	Area, sq. ft									
	Region 1	0	309009	0	0	55690	35054	8902	0	3987
	Region 2	0	0	0	292171	485754	0	0	0	0
	Region 3	55993	106369	239994	0	16753	0	0	27447	0
	Harvest, kg	13334	36452	59248	6840	17196	2311	11582	2490	31106
Plan 2	Area, sq. ft									
	Region 1	0	310406	0	0	54661	35054	8534	0	3987
	Region 2	0	0	0	292171	485754	0	0	0	0
	Region 3	55993	104825	239994	0	18297	0	0	27447	0
	Harvest, kg	13334	36452	59248	6840	17196	2311	11104	2490	31106
Plan 3	Area, sq. ft									
	Region 1	44100	87708	121925	38775	73585	13500	2750	28275	2025
	Region 2	82500	332250	85500	39725	69950	61500	5500	89500	11500
	Region 3	38356	73500	55000	52500	139200	25000	40500	12500	10000
	Harvest, kg	13334	18226	29624	3420	17196	2311	5552	2490	31106

Source: compiled by the author according to [11]

As shown in Table 3.5, region 3 may reduce its input cost by 7%, whereas the input cost in region 2 can be reduced by 43%. Allocation of covered production expenses in regions 1, 2, and 3 is recommended to shift to 46%, 32%, and 22%, respectively, as opposed to the current 40%, 39%, and 21%. If this adjustment is implemented, it could

result in a 59% increase in farmers' overall income, amounting to 856521 MVR, while also leading to a 52% reduction in AgroNAT's expenses, equivalent to 890438 MVR. These changes hold the potential to improve Maldivian food security and enhance the welfare of local farmers [11].

Table 3.5

Model financial outcomes

Plan	Total input cost, MVR			Farmers' income, MVR	AgroNAT's profit(loss), MVR
	Region 1	Region 2	Region 3		
1	1379422	940768	650277	2320583	-
2	1368898	940768	649231	-	–1725364
3	1379422	1344018	696619	1464062	–2615802

Source: compiled by the author according to [11]

The above model proposes the best optimal crops for each region and how the available resources must be distributed to achieve optimization of the available resources and maximize effectiveness and efficiency of contract farming. To implement it small family farmers, require consulting support to move away from the outdated technologies and low productivity.

3.2. Management consulting in training agricultural extension officers

Management consulting of agricultural activities through contract family farming is required to manage agriculture and agricultural business to remain economically viable, providing farmers and food processors with livable wages and safe working conditions. It also bolsters local and regional economies creating good jobs and building strong communities [83], [162]. According to management theorists, management is tasks and activities involved in directing an organization to achieve or realize the predetermined organizational objectives most efficiently. In other words, management is the process of

planning, organizing, leading, and controlling an organization's human, financial, physical, and informational resources to achieve targets and objectives.

Management of agricultural consulting services helps transfer technology through extension service to meet the challenges of food and nutrition security, poverty reduction, and environmental sustainability. Through consulting services, technical knowledge is made relevant. It is transferred to the farmers aimed at adapting knowledge and enabling an environment within which farmers can overcome the constraints they face in adopting new technology and agricultural practices for sustainable development.

Hence through consulting service management, as discussed in Chapter 3.1, farming communities must be guided on the optimal crops and should be supported in assigning their farmlands which is more beneficial to each region and farmers' personal incomes. Farmers should be assisted until they get the grip on how to utilize farming technologies, manage their finances and keep a record of their accounts. This will help the farming communities to see how they are progressing ahead and will help them plan and organize their farm activities. AES officers target and responsibility needs to be centered in meeting the demands of farmers and ensuring farmers satisfaction of their service and hence it is important that these officers are up to date with the latest' skills and knowledge.

To achieve this through management consulting, agricultural extension service officer (AES officers) need to be developed in terms of relevant knowledge and appropriate skills. Fig. 3.4 outlines these dimensions designed for increasing efficiency and effectiveness of the Maldivian family farmers. As shown in Fig. 3.4, AES officers must have the capacity to build the farmers holistically where they are being supported from pre-planning for the cultivation to the point that they harvest and gain a profit. The AES officers must also support and direct farmers in preparing for the next cropping cycle, where they help the farmers in managing their farming expenses and accounts.

An online study conducted on the AES officers in 4 islands named L. Atoll, Sh. Atoll, Hdh. Hanimaadhoo, K. Male, and Adh. Atoll, where agricultural activities are extensively carried out, gave a situational awareness of the AES officers of the nation.

The study shows that like in the farming communities, among the AES officers there is a gender disparity so that 80% of them are males and only 20% are females. As shown in Table 3.6, these AES officers receive in-house training, and more than 50% of the advisory officers receive frequent in-service and professional development training. Only 20% of the of the Maldivian AES officers achieved a professional degree. In contrast, the remaining officers (40%) just completed grade 10 demonstrating a poor professionalism and qualifications.

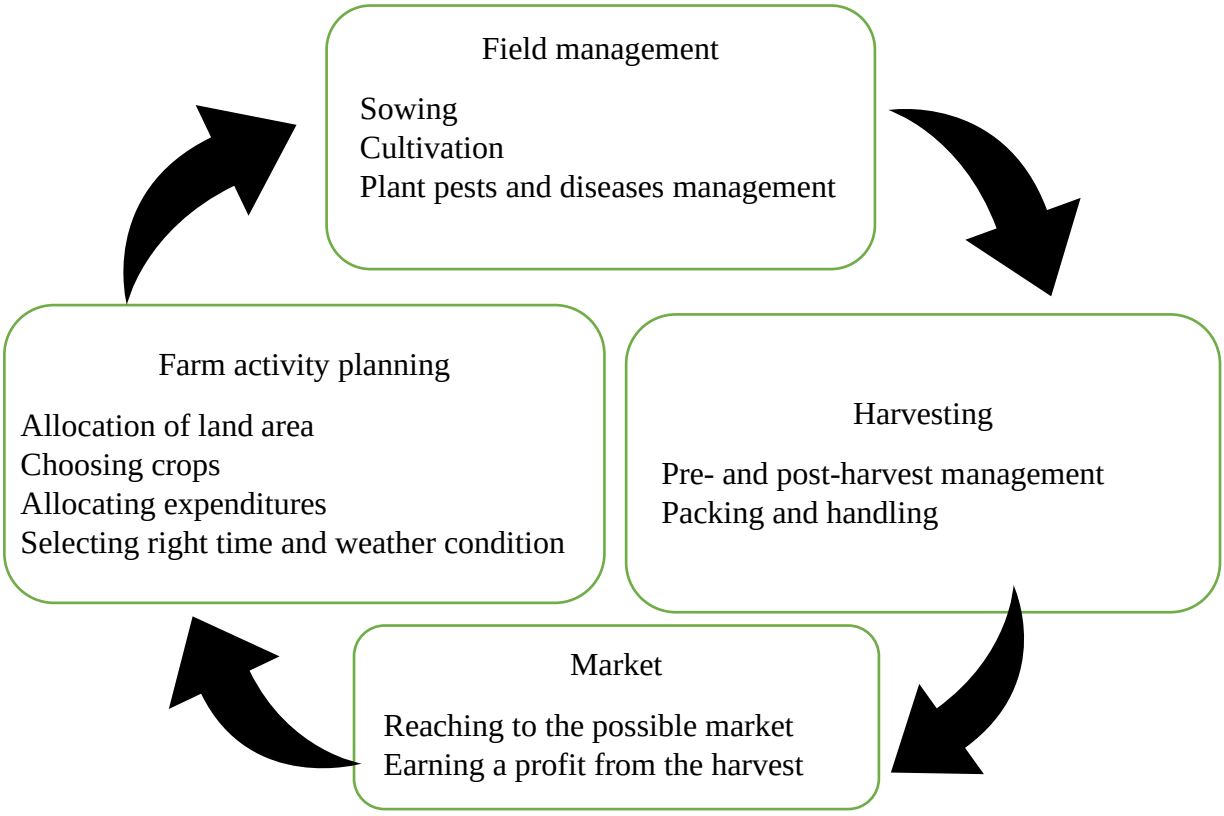

Fig. 3.4. Holistic approach that AES officers must adopt in supporting family farming communities

Source: compiled by the author based on [4]

Despite frequent training, 73.3% of the covered topics are focused mainly on agricultural subjects, and less than 50% are about agricultural entrepreneurship

development, sustainable farming methods and farm management knowledge, as shown in Table 3.7.

Table 3.6

Distribution of advisory workers based on their characteristics

Indicator	Category	Quantity	Share %
Gender	Female	4	20
	Male	16	80
Level of education	Completed grade 10	8	40
	Diploma	8	40
	Degree	4	20
Number of Training	More than 5 training	18	90
	3 to 4 training	1	5
	2 to 3 training	1	5

Source: compiled by the author based on [4]

Table 3.7

Data on AES officer's training

Topic	Quantity	Share, %
Content covered		
Agricultural subjects/topics	12	60
Communication skills	8	40
Leadership/supervision issues	4	20
Administrative and management issues	3	15
Training needs		
Innovative agricultural technologies and farming methods	4	20
Agricultural entrepreneurship development knowledge and skills	11	55
Sustainable farming methods and farm management knowledge	5	25

Source: compiled by the author according to [4]

The educational background and the capacity-building programs these AES officers have been exposed to impact their perception of developing and strengthening the family

farming communities of the Maldives. As shown in Table 3.8, 90% of them believe that their role is to increase agricultural production, and less than 50% of them think that they do not have a role in contributing to national food security, preventing malnutrition, and alleviation poverty. According to their perception, they should only intervene in farming communities when there is a need to intervene. In other words, they believe that farmers must come forward and request information and support they need for which they cater. More than 60% of the AES officers believe they have no role in connecting the farming communities with the stakeholders, such as input ad market suppliers. In addition, AES officers strongly think they need public speaking, supervision, and leadership skills to carry out their function in consulting.

Table 3.8

Roles played by the AES officers

Aspects of advisory service	Quantity	Share, %
Increasing agricultural production	14	93.3
Improving rural livelihoods	6	40.0
Facilitating linkage between research centers and farmers	8	53.3
Rural development/poverty reduction	3	20.0
Promoting gender equity or women's participation	6	40
Helps farmers gain access to credit/farm inputs /markets	6	40
Facilitating coordination across other sectors	3	20
Collaborating and strengthening the NGO network	5	33.3

Source: compiled by the author according to [4]

This study also reflected on the AES officer's perception of advisory approaches and methods of their development. They firmly believed that agricultural support services must be provided to the farmers based on the demand-driven advisory system approach that caters to their needs and wants. Table 3.9 also shows that 60% of the farmers believe that they have no role or say in what system of agriculture or farming is implemented in

the country. In other words, they believe their purpose is to provide information and knowledge when there is a request from the farmers.

The above results show that in order to meet the goals and objectives of the AgroNAT company, it requires a competitive, critical-thinking AES officers who work towards building, strengthening, and scaling up the agricultural activities of the farming communities to ensure that the country moves towards providing national food and nutrition security and increasing the local production to eliminate sharp dependency on agricultural imports.

Table 3.9

Perception of AES officers towards advisory approaches/methods and their development

Aspects of advisory service		Advisory workers have no say on what system is introduced in the country	NGO advisory service is more effective than public sector advisory service	The pluralistic advisory system (public, private, and NGO system) is successful in my country	The demand-driven advisory system (based on farmers' needs and wants) is successful in my country	The privatization of the advisory system is mainly the result of a lack of confidence in the public advisory system
Level of agreement, %	agree	60	6.7	33.3	46.7	60
	strong agree	6.7	26.7	6.7	6.7	5
	disagree	26.7	33.3	20	13.3	26.7
	strongly disagree	0	6.7	6.7	0	1.6
	neutral	6.7	26.6	33.3	33.3	6.7

Source: compiled by the author according to [4]

Most of the farmers in the Maldives are small-scale farm holders. According to studies for small-scale holder farmers to become more entrepreneurial, the AES officer's

assistance and institutional support are invaluable. There are many reasons for the AES officer's inability to deliver knowledge and skills to the farming communities, including time, money, and other logistical difficulties that prevent them from outreaching the farming in remote rural areas [10].

AES officers must promptly provide farmers with suggestions, plans, and ways to optimize their resources and maximize their income based on their opportunities. Besides AES officers must link farmers with knowledge and information on weather and climate changes, market prices, regulatory structures, and quality standards.

Based on the above, the Maldives AES officers' capacity must build through the consulting service management to help the farmers implement region-specific measures proposed by the optimization models in allocating resources, selecting crops, and implementing the technology-based farming method to increase the production of target crops.

Consulting services in agricultural management must build AES officers who can work with geographically dispersed farming communities of the three regions whose access to resources, finance, and market varies and whose production is greatly challenged by plant pests and diseases issues. These officers' capacity must be built to make the farmers understand and implement farm strategies that will increase their production, reduce its cost, and raise their farming income. In addition, AES officers should support the farmers in good agricultural practices as well as in farm monitoring and management measures to ensure higher yield production at the end of their harvesting cycle.

Hence, the consulting service management must develop AES officers who can carry out the following farm management strategies: region-specific, resource efficiency, economic and technical efficiency, centered around production optimization. As discussed below, allocating natural resources and selecting crops must be distributed among regions to ensure that family farming activities are managed effectively and efficiently [11].

According to optimal production found in Chapter 3.1, AES officers assisting farmers in region 1 should be prepared to provide a holistic consultation on planning, field management, harvesting and market advantages when growing recommended beneficial crops such as banana and cucumber.

Namely, the AES officers need to be aware that the Maldivian farmers usually implement conventional propagation methods and rely on banana suckers which limit and hinder the productivity and profitability of this crop. The AES officers must provide the banana farmers with alternative strategies, such as tissue culture bananas. Hence, the consulting service management must build their skills and knowledge in introducing tissue culture banana cultivation on 75% farmers lands in region 1.

Tissue culture banana plants produce high-quality bananas with high yield, consistent growth, and year-round plantation, which meets the high standards set by the Maldivian resort market. AES officers need to have knowledge in helping the farmers set up their farmlands, plan tissue culture banana plants, and support them in maintaining the banana plant fields. They should be able to train the farmers and provide regular weeding management procedures and water requirement information that they must follow to keep the banana fields healthy. They should also inform the banana farmers when to remove the male flower bud and know the measures that must be taken to help them produce quality bananas. That is, they should inform and make the farmers bag the banana bunches, to prevent insects and bats from damaging them to ensure that at the harvesting point, the farmers can produce A-grade quality bananas.

AES officers should be built with the capacity to make the region 1 farmers train and support them in proper harvest and handling procedures in harvesting banana bunches and ensuring that banana bunches remain fresh and of high quality until they reach the market point. AES officers must have the capacity to plan. They should know the sector-specific information and help the banana farmer connect to the market points after it is harvested.

In addition to this, AES officers who work along with the family farming communities of region 1 should support the farmers to use 10% of their arable land to produce Riches variety cucumber so that these farmers can earn a higher income with the given allocation of land resource for cucumber.

Through the consulting service the AES officers ought to introduce the ways to connect the farmers of region 1 with the possible market avenues for their production and directing the farmers to such market points. For example, AES officers of region 1 should be aware of the number of cucumber harvests from this region and then, through careful planning, must direct the farmers to the buyers or market so that the farmers' produce is being sold without going to waste.

Looking at region 2 based on the optimal plan 1 and plan 2, it requires 38% of land for butternuts and 62% of the land for cucumber growth. Thus, AES officers should encourage farmers in region 2 to maximize the production of cucumber and butternut, as these two crops will be more beneficial for them. The farming activities' efficiency and effectiveness must be enhanced by optimizing the use of 38% and 62% land. Hence, the AES officers must support the farmers in achieving this target. Among the Maldivian farmers and based on demands, farmers must grow *Madam* cucumber variety and *Riches* cucumber variety.

Madam cucumber variety can be grown in the open field with strict monitoring and control measures to produce quality products. Hence, AES officers need to guide the farmers from the point of sowing to the point of harvest on what must be done and how often they should monitor the plants, water them. It implies practical visits and demonstrations of the hand pollination of the cucumber plants to produce quality products. This is because, in most cases, though the farmers use hybrid cucumber seeds, it requires hand pollination to reduce deformed shaped cucumbers, which results in loss of value. Not to mention that the farmers also need to have a sharp eye on the plant pests and diseases to ensure that the fruiting stage plants and fruits do not get wasted. Therefore, the AES officers must regularly keep informing and collecting data on the fruits and the plants

to ensure that at the end of the harvesting cycle the farmers can produce the expected amount of yield.

Similarly, the AES officers must guide the farmers to allocate farmland areas to grow *Riches* cucumber variety. These cucumbers cannot be produced in the open field, requiring a controlled environment for this crop's booming growth which can be provided by means of the growing bags with cocopeat in a greenhouse or hydroponic system. Through the consulting service, the AES officers who work with the region 2 farmers must be trained to have sound knowledge in building greenhouse structures and hydroponic systems in a cost-efficient manner. They need to know how to maintain these structures to convey this knowledge to the farmers and train them to use such a system.

The method mentioned above for farming cucumber is expensive and requires enormous investments. AES officers should have the knowledge and skills to support the farmers to acquire credit loans to get finance to start up this method of farming. In the Maldives, there are credit schemes established by the Ministry of Economic Development (MED) as well by MoFA which help the farmers to access credit loans to start new businesses where they have a priority for rural farmers. Hence, the AES officers of region 2 should be aware of the procedures for helping the farmers access these loans and credits. Moving further, the AES officers should be able to do financial analysis, cost analysis, and how farmers will recover the investment to empower the farmers to go for such assets, which will further motivate the region 2 farmers to start technology-based farming methods. At this point, the AES officers should apply critical thinking and take responsible actions to ensure the sector’s development. Technology-based farming methods require knowledge, skills, and energy. It also demands young people to get the grip of technology-based farming methods and has the stamina to move ahead with their young creative-thinking minds. Hence, the AES officers should critically reflect on the matter from this perspective and push the young farmers of the region 2 to learn and start adopting these technology-integrated farming methods in growing cucumber. In this sense, more young farmers can also be recruited to the sector.

Along with the type of growth medium for the cucumber, the AES officers also need to have sound knowledge and skills in training these farmers in harvesting and handling techniques of cucumbers. In addition, they must have information and knowledge of nearby possible markets, such as resort markets to whom the produced cucumbers can be supplied, to ensure that these farming communities gain a profit and cover their expenses. Packing and handling of cucumbers can be managed cost-effectively by using locally produced bags and instructing the farmers on keeping the harvested fresh until it reaches the market point. Simultaneously while supporting the farmers in managing their fields, AES officers must ensure keeping the farmers informed and connected with possible logistical routes and market points.

Region 2 AES officers need to allocate 38% of their land for the growth of butternut, which also requires much attention in managing plant pests and diseases and careful handling of the crop so that the skin does not get damaged, resulting in a loss of market value. In other words, the AES officers should have the required skills and knowledge to support the farmers who grow butternuts on 38% of the land of this region [1]. Compared to cucumber, butternut has a longer shelf life, and consequently, AES officers can help the butternut farmers to transport their produce to long-distance market points away from their farming island, which might take more than 1 or 2 days to reach the market. Using leaves between the butternuts when stacking them and wiping them with a wet cloth piece are zero-cost required measures that rural farmers from different parts of the world practice to maintain their product quality. It means that the AES officers can also help the region 2 farmers to practice such zero-cost measures to preserve the quality of the harvested produce.

According to the optimization plan, region 3 farmers should prioritize growing more watermelons as their first crop and, secondly, bananas. The optimum yield for region 3 is watermelon, where the farmers must allocate 54% of their land for the growth of watermelons and 24% of their land for cultivating bananas. The AES officers who work with the region 3 farmers, like region 1 AES officers, should comply in supporting,

directing, and monitoring banana farmers to maximize the banana production from the 24% banana land share.

Shifting the focus on the 54% land share under watermelons in region 3 the AES officers should have enough knowledge and skills to support growing high quality watermelon yield because watermelons have a guaranteed market from resorts and local consumers. There is no risk of being unable to sell as the demand for watermelon is continuous throughout the year, and there is a massive swell-up in the demand curve during Ramadan. Along with the cultivation, sowing, plant pests and diseases, the AES officers must pay attention to watering the watermelon vines at the seedling stage and the fruiting to fruit maturity stage. These AES officers should closely monitor and guide the farmers on how they must water the watermelon vines to prevent mold and fungus from developing due to excess watering. The AES officers must do scheduled monitoring and close observation in guiding and supporting the watermelon farmers when the fruits are maturing stage, as watering the fruits directly at a high volume in the middle of the day when the temperature is high results in bursting watermelons and farmers' losses. Unfortunately, this is a common phenomenon among watermelon farmers. In addition to this, harvesting watermelon also requires special skills. The AES officers must ensure that the region 3 farmers have these skills and tactics so they don't harvest unripe watermelons, which will lead to a loss for the farmers. For example, farmers should know commonly used watermelon maturity indicators, and the AES officers should make sure that farmers follow these indicators when harvesting the fruit. Watermelon is a short shelf-life crop that must be appropriately handled after harvesting and during transportation. The AES officers should affirm the farmers to take precautionary measures to ensure this.

Along with the watermelon region, 3 AES officers should have strong knowledge and skills of growing, harvesting, packing, and transporting brinjal. They should also be aware of the potential market and logistical routes to these markets. They should guide the farmers and direct them to such avenues so that they can sell their produce. There is a deficient brinjal production among the brinjal farmers due to common diseases that

damage brinjal plants throughout the Maldivian farming communities, known as shoot and fruit borer insect disease. This is a tiny insect that, at the very early stage, bores into the stem and enters the fruit, damaging the fruit inside without showing any visible signs. Careful observation can help the farmers identify if the fruit is damaged by a tiny, tiny hole that is mostly invisible. South Asian farmers and other farmers who grow brinjal use pheromone traps and other methods to control this disease. Hence, the AES officers must support the brinjal farmers to tackle this issue and enforce and train them to monitor their fields and control this disease to get quality produce.

The consulting service helps the AES officers who work with the farmers respective to each region master skills and knowledge to optimize region-specific optimal crops. Along with specific knowledge and skills, all AES officers should know about increasing the farmers' technical efficiency regardless of their region.

Hence the consulting service is crucial and must develop the AES officers with knowledge such as establishing irrigation systems and using appropriate farm equipment to reduce labor extensive farm activities such as manually digging pits in substantial land areas. Given that the Maldivian farmers are challenged due to the scarcity of freshwater, the AES officers must be equipped with the knowledge to build irrigation systems such as drip irrigation. Farmers must be supported with irrigation and sprinkler systems to achieve technical efficiency in watering their watermelon fields. Moreover, AES officers should know about implementing measures to help the farmers collect and store rainwater so that the collected water is safe for farming purposes.

In addition, all the regional farmers must be supported with irrigation systems, watering mechanisms, and machinery to reduce their labor time to increase their productivity and efficiency, given that farmers all over Maldives lack access to such equipment and tools. To move the family farming communities away from conventional methods of farming as well as conserving the available water resource, irrigation must be built for the farmers. Along with the technical efficiency, this will also help sustain natural resources such as water and soil nutrient conditions [1].

All the family farmers from all three regions must be supported with credit facilities and financial support to invest in their farming equipment such as plowing machines, weeding tools, and other ones that will reduce their labor work to make time for more productive farming activities such as pollinating flowers, monitoring the field and managing the farm accounts. The AES officers must know how to plan and guide the farmers in distributing and allocating expenditures for farm activities that benefit them most. On this note, the AES officers must help in allocating cost on agricultural inputs, chemicals, fertilizers, tools, and equipment, by 46%, 32%, and 22% for regions 1, 2, and 3, respectively, which directly correlate to the growth of the optimal crops concerning each region [11].

AES officers also should be trained and equipped with knowledge in establishing harvest handling areas such as pre-cooling before packing and proper cleaning techniques for fruits and vegetables. Hence, AES officers should impart and guide the farmers to put these measures into practice to produce higher quality produce. Moreover, if required, the AES officers should be able to guide and help the farmers build such areas. Hence, regarding this aspect, through consulting services, the AES officers must be prepared to arrange such harvest handling areas.

The importance of consulting services is vast, and their support in building strong AES officers who will strongly influence the production patterns of the farming industry is evident. By training the AES officers, consulting services in the agricultural sector address the social, economic, and environmental aspects of the farming communities. Ensuring a viable income through enhanced production and establishing market connections means that the social well-being of these farming communities is alleviated. The AES officers' support is not gender specific. Thus, all the farmers, regardless of gender, are pushed to advance. This maintains a guaranteed income and better healthy living for the farming communities. Malnutrition will be addressed by increasing the daily calorie intake as the farmers earn a better-sustained income.

Economically the farmers will be strengthened with the help of consulting services. The AES officers will be able to support the farmers in acquiring credits to buy machinery, tools, and equipment and establish technology-based farming methods. AES officers' guidance in implementing irrigation systems, collecting and storing water, and directing the farmers to implement good agricultural practices that reduce waste and other chemicals helps the farming communities sustain the available natural resource.

The above production, technical, economic, and resource efficiency can be achieved by implementing consulting service management in training and building AES officers who can help the farming communities to optimize production and maximize the efficiency of the available resources concerning each region. The above-allocated land allocation to each region would double the production of bananas, watermelon, butternut, and melon. These high cash crops have massive demand from the locals and the resort markets. The expenditure allocation concerning each region will reduce the wastage of inputs by the farmers which is being practiced currently. The optimal crops will reduce the unnecessary expenditure on the growth of less productive crops in that region.

3.3. Labor force improvement in family farming

Education through Information and Communication Technology (ICT) plays a huge role in empowering rural farming communities to gain knowledge and skills to enhance the farmers' productivity. Integrating ICT in agricultural farm management and enhancing farming communities' production and growth is the 21st-century management strategy widely used among South Asian countries, positively impacting the sector. ICT mode helps collect current information, deliver knowledge, and introduce skills. It is a medium for disseminating this information, including mobiles, computers, laptops, and tablets [78], [87].

By and large, ICT is an efficient tool to scale up smallholder farmers to enhance the farmers' efficient and effective management of farm activities. For instance, in India they

use mobile apps with over 200000 smallholder subscribers from 10 different states to access prices, commodities, and advisory services, which provide information on 150 crops and outreach to more than 1000 markets for $1.5 per month. Utilizing this cost-effective ICT strategy reduced 50% of spending on agricultural inputs and generated $2–3 billion in income for farmers [158]. These call centers operate successfully in 50 states, providing short-term crop growth consultations and information for longer-term activities through weekly conference calls with topical experts [115].

Another successful example of ICT integration is Tamil Nadu, women farmers who raised livestock have significantly benefited from voice messages shared through mobile phones based on their requirements. These farmers have limited access to farm-related issues, which are tackled by providing information on market access, innovative agricultural practices, and inputs through ICT, which address limited availability of such facilities due to gender-specific issues of different communities [158].

Mobile technology is the most used technology and is adopted by farmers worldwide as a delivery medium of agricultural-related information and solutions. Like most developing countries, the Maldives also has leaped from hand phones to mobile phones throughout the country with no difference between urban and rural areas. Regardless of which island community farmers belong, they have access to mobile phones, which have become the primary mode of communication in the nation.

Though family farmers of the Maldivian farming communities are challenged in accessing the latest relevant agricultural information due to the remoteness of these rural areas and the long distance in outreaching, most female and male farmers have access to smartphones and acquired digital skills. Given the living standards of these farmers, they all have access to the national radio and TV. ICT is a possible means of connecting farmers in even the remotest locations by clicking through mobile phones and helping them overcome knowledge gaps and improve their business [40].

Table 3.10 below shows that among the contract farmers of the Maldives, 340 have access to Nokia phones regardless of age and gender, whereas 119 of the farmers still use

Nokia phones as a mode of communication independent of gender and age. Among female farmers, 81 women above 40 have smartphones, which is higher than the number of farmers with access to smartphones in the under 40 age group. Similarly, this trend can be seen among men, where more male farmers above 40 can access to smartphones.

The analysis of the profiles from Table 3.10 was conducted via the Chi-square Test for Independence of two categorical variables with two grades. The considered frequencies available from Table 3.10 were denoted as N_{11}, N_{12}, N_{21}, and N_{22}. The Chi-square value of X^2_{calc} is calculated by the following formula:

$$X^2_{calc} = \sum_{i=1,2} \sum_{j=1,2} (N_{ij} \cdot N - (N_{i1} + N_{i2}) \cdot (N_{1j} + N_{2j}))^2 / ((N_{i1} + N_{i2}) \cdot (N_{1j} + N_{2j}) \cdot N), \quad (3.8)$$

where $N = N_{11} + N_{12} + N_{21} + N_{22}$.

Table 3.10

Profiles of mobile phones provision among contract farmers in the Maldives

Phones	Females		Males	
	under 40	above 40	under 40	above 40
Smart	18	81	58	183
Nokia	0	28	1	90

Source: compiled by the author according to [10]

The respective critical Chi-square value of $X^2_{crit}(df, \alpha)$ should be consistent with degrees of freedom df = 1 and a conventional level of significance α=0.05. In the case of true inequality

$$X^2_{calc} \leq X^2_{crit}(df, \alpha) \quad (3.9)$$

it is concluded that the examined categorical variables are independent and vice versa.

Firstly, this method was applied to compare smartphone access among females and males under and above 40. The performed analysis (3.8) based on the inequality (3.9) revealed that the explored variables of gender and age are statistically unrelated regarding the farmers' provision with smartphones:

$$1.40 = X^2_{calc} \leq X^2_{crit}(df, \alpha) = 3.84. \quad (3.10)$$

Secondly, the Chi-square Test for Independence was used to examine the relationship between the availability of phones and the gender affiliation of farmers above 40 years old:

$$1.93 = X^2_{calc} \leq X^2_{crit}(df, \alpha) = 3.84. \quad (3.11)$$

Similarly, according to inequality (3.11), there is no statistically significant relationship between the compared categorical variables. Thus, both Maldivian female and male farmers use mobile phones in the same way.

Given that more than 78% of female and 73% of male farmers have access to smartphones despite the higher number of male and aged farmers involved in farming, improving AES for the whole rural farming communities in a uniform manner is justified. It ensures access to urgent agricultural information, which might be a successful solution to address farmers' concerns.

Access to the internet is available to all Maldivians regardless of how remote the island is. This is a possible means to encompass or connect all members of farming communities through smart and Nokia phones. Farmers can be connected via text messages to access information in every aspect of farming, from sowing to the market point. As given below, the context of these text messages can be tailored as follows [40], [87], [120].

The first messaging topic is technical information. One major challenge male and female farmers identified is that they need support and guidance in sowing, monitoring their fields, applying fertilizers and chemicals, and determining when to harvest their crops. The mobile application connecting the farmers with the required information source by sending a text message or picture, which is replied to instantly, can solve the issues the farmers face in their daily routine farming activities.

The second messaging topic is crisis management information. The Maldivian farmers have two seasonal changes impacting their farming activities: the dry and rainy seasons. These two seasons threaten smallholder farming communities, such as crop-

specific plant pests and diseases outbreak. These two seasons also favor certain crops to be grown depending on the nature of the crop. Mobile alert messages on how seasons are changing and what preventive measures farmers must take at a specific time of the year can enhance their production by optimizing their time, land, and resources.

The third messaging topic is weather forecast information. Over the past few years, the Maldivian unpredictable weather conditions, such as swelling up waves, a heavy gush of rains, and tsunamis, were linked to the extreme weather conditions that hit the neighboring countries such as India, Sri Lanka, and Bangladesh. Maldivian crops were destroyed, leaving farmers penny less. Thus, weather forecast information keeps farmers informed and prevents them from making decisions based on rumors, past experiences, and wrong perceptions.

The fourth messaging topic is market information. Farmers' production does not capture market value as farmers have no access to market points, market data, and information about suppliers of inputs which will help them plan and invest in farming activities to ensure efficiency. Sending farmers text messages about the possible market points nearest to their farming communities, prices, and transport vessels helps them target their production based on market demands and reduce the wastage of their produce. In addition, having access to suppliers' information allows farmers to get quality farming inputs on time and make efficient farm decisions.

To further strengthen and support the family farming communities in an equal manner, the differences among farmers regarding their digital skills must be addressed. This will help connect all the farmers despite their economic level, education, and age, keep them well-informed and effective in farming activities.

Table 3.10 also displays that 22% of female and 27% of male farmers have no digital access. AgroNAT farmers are bound to a credit scheme upon signing the contract, which includes all the support required to start farming, covering capital and recurrent costs. Hence to engage those farmers who lack digital access, they should be provided with smartphones at a 20% discount rate which can be distributed for one year. A

smartphone that farmers use to inquire about farming information costs 3000 MVR, less than $200. Farmers who meet 90% of the forecasted production will be given a higher discount. Besides, a farmer who produces papayas in 5000 sq. ft could pay the phone price within one harvest, which is comparatively affordable.

In addition to text messaging the AgroNAT corporation implemented GOVAAN application to address farming-related issues. This is a mobile application that farmers and AES officers can use online. It's a comprehensive application that guides the farmers from the planning stage to the point where they receive the payment for their harvested product.

The GOVAAN app is an ICT-based platform that can be used as mobile support for farmers to achieve sustainability. It is an application that can be used by any individual regardless of their knowledge and skill in farming. That is, it helps the farmers to plan their activities, starting from how much input (fertilizers, seed variety, etc.) is required, steps to follow in land and pit preparation, how to monitor farming fields, how and when to apply fertilizers, when and how to pollinate and attend the area to the harvesting point. In addition, through the application farmers can estimate the expected yield by the end of each harvesting cycle that further helps manage farming input costs to assess necessary investment to profit from the harvesting cycle.

Through this application, farmers can tackle plant pests and diseases issues. To do it, farmers need to take pictures and upload them, and qualified agronomists will send suggestions and measures. At the harvesting point, farmers will be guided through GOVAAN app on when to harvest and what to harvest, and how it must be handled. Farmers will be given a forecasted amount that can be produced, which helps the farmers to set targets and work towards achieving these targets.

AES officers trained through the consulting service and the GOVAAN app will help the farming communities plan their farming activities and achieve optimization. One of the unique features of this application, which give an advantage over the other farmers who do not use this platform, is that farmers who use this GOVAAN app will be directed

and connected to possible buyers. Available logistical and market point information will be shared and viewed by them before the harvests.

Along with the digital support, AES officers should be ready to consult farmers in person in the fields. This capacity implies them to be equipped with the knowledge and skills required to support the family farming communities with farm management and entrepreneurial skills to assist farmers in planning and organizing their available resources in such a way that will optimize their production. AES officers must work with local NGOs and outreach farmers, especially women farmers, to share information for improving family nutrition and well-being in rural communities [12], [158]. The advisory system of the country operates as a one-way (top-down) where the top management dictates the advisory approaches and methods without any involvement of AES officers. This needs to be changed to increase the participation of the AES officers by strengthening the linkage between different stakeholders and allowing AES officers' opinions and requirements to be heard in addressing issues faced by the farmers [157].

Similarly, AES officers must support the family and small-scale farmers to become more entrepreneurial. Entrepreneurial means farmers look for opportunities to improve and expand farm activities by calculating risks and assuming responsibility for profits and losses. As a result, such entrepreneurial farmers start producing for the market [31], [84].

Analysis carried on understanding the time taken by the AES officers to reach the farming communities shows that it is time-consuming. The time taken to outreach these farming communities and the associated expenses prevent the AES officers from visiting the farming communities more than 2 or 3 times a year. It has a negative effect on implementing strategies to sustain farmers' environmental resources and achieve economic sustainability. As shown in Table 3.11, it takes up to 6 hours to travel by boat or by air between some of the most active farming communities. It implies that AES officers need to adopt an optimal route that will save time and money in outreaching even the remotest islands and atolls with family farming communities who require AES

officers' support and personal presence in carrying out agricultural activities or tackling crop-specific issues.

The developed integer linear model is meant for searching for a one-cycle route to visit each island within the quickest tour. For this to happen, the model introduced binary variables X_{ij}, which equal 1 if the tour goes from i-th to j-th point, i=1…8, j=1…8. To ensure a single entry to and exit from every island, the model variables are subject to the following restrictive equalities

$$\sum_{j=1\ldots8} X_{ij} = 1,\ i=1\ldots8, \quad (3.11)$$

$$\sum_{i=1\ldots8} X_{ij} = 1,\ j=1...8, \quad (3.12)$$

$$X_{ii} = 0,\ i=1\ldots8. \quad (3.13)$$

Table 3.11

Time (in minutes) taken to move between islands in the Maldives

From / To	#1	#2	#3	#4	#5	#6	#7	#8
#1	0	30	40	50	360	225	235	235
#2	30	0	10	15	360	120	125	130
#3	40	10	0	20	255	120	125	130
#4	270	15	20	0	360	225	230	235
#5	360	255	255	360	0	225	230	235
#6	225	120	120	225	225	0	10	100
#7	235	125	125	230	230	10	0	110
#8	235	130	130	235	235	100	110	0

Source: compiled by the author according to [10]

Besides, auxiliary integer variables $2 \le U_k \le 8$, k=2…8, are designed to maintain a one-cycle route according to constraints

$$U_i - U_j + 8 \cdot X_{ij} \le 7,\ i \ne j,\ i=2\ldots8,\ j=2. \quad (3.14)$$

Finally, given the parameters C_{ij} from Table 3.11, the model objective function looks like

$$\sum_{i=1...8} \sum_{j=1...8} Cij \cdot X_{ij} \to \min. \quad (3.15)$$

The optimal solution to the stated model was calculated by means of the Solver tool built in the MS Excel spreadsheet. It found the optimal route with an arbitrary starting point, such as

Ha. Baarah → Hdh.Vaikaradhoo → Hdh.Nolhivaranfaru → Raa.Kinolhas →
N.Manadhoo → L.Gan → L.Fonadhoo → Hdh.Nolhivran.

It would take AES officers at least 825 minutes or 13 hours and 45 minutes to attend the 8 largest islands participating in contract farming. This route optimizes time, effort, and expenses in outreaching these rural farming communities by sea and air transport.

This optimal route is an improvement measure that can help address the support required for education and technical assistance, starting from sowing, cultivating, harvesting, and marketing information needed for the farming communities, as shown previously in Fig 3.4. Such AES consultations are especially valuable for women farmers. Indeed, the study in Chapter 2 and the focus group discussions revealed numerous challenges female farmers face due to a gender disparity among the family farming communities. Supporting the women farmers with information facilitating their farm decision-making will empower the rural female farmers who contribute to farming activities to support their families [4], [10].

Moreover, this will help the marginalized women farmers independently carry out their farming activities and earn an increased income without depending on their male partners, improving their lives. Educating women farmers on capturing market value and connecting them to the market will ensure they retain their crop value to the middleman.

One main challenge women farmers face is access to land ownership. Measures must be taken to increase women's access to common lands, determined by patriarchal land rights that underpin many customary land rights systems. Women farmers also encounter gender inequality in the credit market, which can be eliminated through their education via mobile texts and AES consulting on farming knowledge, financial, and farm management skills.

One constraint that all women of developing nations face is the burden of house chores and childcare responsibilities that they are bound to, which restricts them from taking part in economic activities. This burden needs to be eased through social development at the government and institutional levels. Through small grants and funds, women should be empowered to carry out farming activities that are less labor-intense such that they can carry the farming activities along with house duties and responsibilities.

They need to be given a voice to represent them and start farm businesses, which can facilitate women's participation in out-grower schemes through access to credit. In addition, women farmers need to be supported with some income to support their families and ensure their household is food security. Hence, females can invest time and money in pushing and scaling up their farming activities. It is also essential to include women in decision-making roles when it comes to farming activities. Through contract farming, family farmers must be respected in consulting and planning farm activities with the family farming household rather than relying on opinions from men elites.

Further, the Maldivian agriculture requires energetic young, vibrant farmers to integrate farming technologies to improve the efficiency and effectiveness of farming activities. Also, investing and scaling the farming business with a good understanding and acceptance of the future of food systems and the changing global world requires young farmers.

The research studies carried out in Chapters 2 and Chapter 3 show that there is a high prevalence of old-aged farmers among both women and men. These farmers need better digital literacy to sustain farming activities.

In addition, credit lenders, banks, and investors are not willing to invest in old-aged farmers to scale up their businesses and implement integrating technology-based farming methods as there is no guarantee that their credits can be repaid back or that farming activities can be carried out sustainably.

To build active young farmers and the agricultural sector, the Maldives education system must implement courses and professional development programs that develop

agricultural field-related experts focusing on Maldivian crops. In addition, there is a need to recruit and retain youth who can manage agricultural activities in terms of economics and financing farming.

In the Maldives, the young are considered between 18–35 years of age. As shown in Fig. 3.5, in 2021, more than 50% of the youth concentrated within the island communities with fewer income-earning opportunities, whereas 44% of the young lived in the capital city.

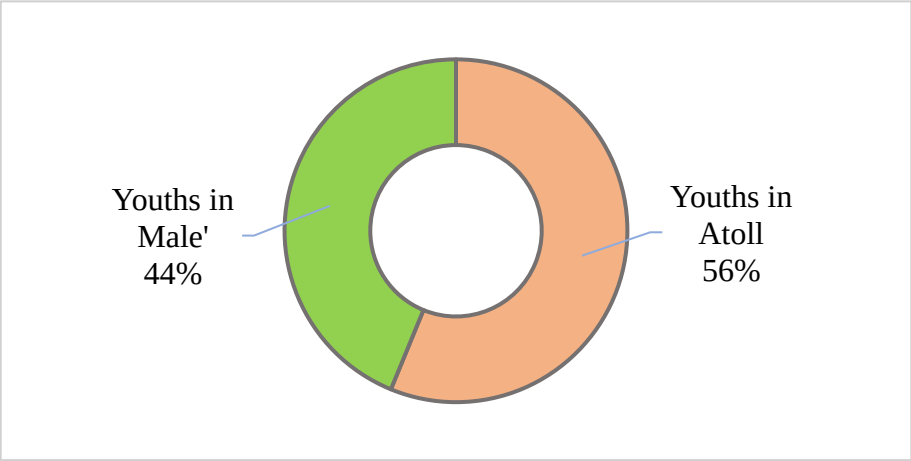

Fig. 3.5. The youth distribution in the Maldives

Source: compiled by the author according to [81]

In addition, as depicted in Fig. 3.6, 77% of the young or 198055 people have completed their secondary level of education. However, among the youths of 257215, only 12% have completed the tertiary level of education.

According to statistics, the unemployment rate among the youth population within the atolls is higher than in the capital city [185]. It shows potential for developing youths with skills and knowledge to provide them with secure income-earning opportunities through farming activities.

The Maldives is a country that imports massive amounts of fruits and vegetables, which requires technology-integrated farming methods such as hydroponics and grow bag

mediums, as discussed in Chapter 3.2, which will increase farming production and increase income. Thus, this is an excellent opportunity for the youths to invest in the farming sector to develop themselves as farm entrepreneurs. Most of the young population who finish their secondary standard of education due to the lack of access to training facilities and earning opportunities migrate to nearby resorts in search of income-making opportunities. This weakens the whole island's farming and economic activities, leaving the island economically, socially, and environmentally underdeveloped.

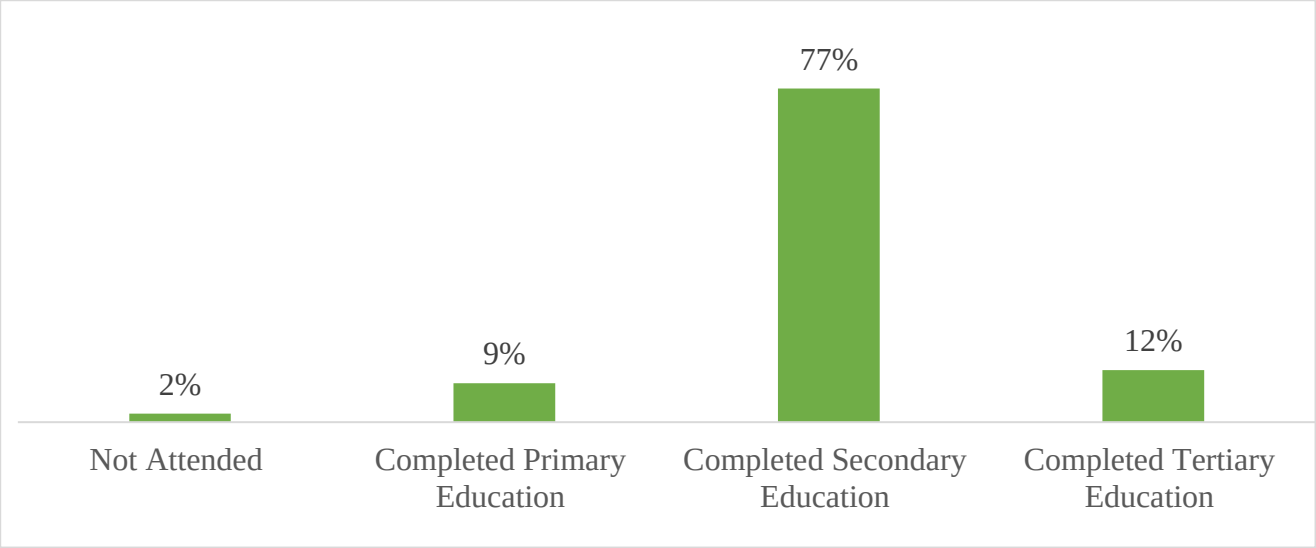

Fig. 3.6. Levels of education among the young in the Maldives

Source: compiled by the author according to [185]

According to statistics, the Maldives youth population, which falls under the age group 18 to 35, are employed in the public administration and defense, compulsory social security, education, wholesale and retail trade, motor vehicle repairing services, transportation, storage, and manufacturing work. The youth participation in farming activities is not even recorded in the Maldives' statistical yearbooks due to too few youths in the sector [185].

The research findings on developing young people in the agricultural sector are as follows. The future of the Maldivian agricultural sector and its ability to ensure food and

nutrition security, driving the country away from import dependency, is determined by developing, recruiting, and retaining young population. Without the youths being part of this sector, the future of the local food supply is uncertain.

To attract the youth and develop them into the sector, the sector must be integrated with technologies to move away from labor-intensive methods of farming and increase the quality and quantity of yield that meets the demand of the local and resort market. Most importantly, the stigmatization around farming activities and agriculture sector jobs must be addressed, which is still believed to be for the uneducated, retired, and middle-aged homemakers. This stigma must be reduced to recruiting young people into the sector as a viable, increasingly profitable, and stable career option.

To recruit young farmers into the sector, it must change the image of agriculture. Along with the education and skill-building programs, it also must focus on changing the mindset of the already existing farmers involved in farming activities. Their perception of farming as labor-intensive and dirty work should be altered by introducing technology-based farming methods, equipment, tools, and gadgets that will increase the efficiency of their work with less time and effort. The farmers need to be ensured that farming activities can be carried out with the help of technologies to produce higher quality products which will provide a guaranteed market for their produce, and this will improve the image and perception of young people to think of farming activities as a viable career option. For example, using irrigation systems in large banana and papaya fields, digging tools for making pits in the areas, and automatic systems in controlling the temperature and sensors which automatically water the fields, which requires minimum farmers' attention and time, will change the mindset of the existing farmers as well as it will attract youths who search for jobs in the job market.

In addition to this, the training and skill development programs farmers need to be supported to focus on farming activities through a business lens which reflects on how individuals can invest in starting farming through advanced technological methods and

how they can scale up their business, and how much they will earn which is a guaranteed income way better than other sector jobs.

Moreover, students should be given intern opportunities and hand on experience in operating and working in agricultural farms with integrated technologies to expose them and build their mindset towards agricultural sector careers. For example, students who complete their higher secondary education can be given opportunities to work as interns or go on field trips to well-established agricultural farms in different countries to expose them and develop their mindsets into it.

Also, in partnership with schools and universities from neighboring countries, children and teenagers can be exposed to the farming business. This can be further strengthened by integrating food, nutrition, and other related subjects into the curriculum. Exposing young learners and youths to such issues early can develop problem-solving and an overall interest in agriculture and the food sector.

Retention and retaining youths are as essential as developing youths in the sector. In the Maldives, due to the high share of expatriate teachers' government implemented a policy in early 2005 to provide paid leave for the youths who participate in teacher education training and a guaranteed job at schools, which led to a bloom in the local professional teachers decreasing the expatriate teacher population. More than 100 scholarship opportunities were provided for youths who finished their higher secondary education to train themselves from abroad to become professional educators who are obliged to work in the education sector. Similar initiatives can be taken to recruit and retain young people by providing scholarships, training opportunities to develop themselves to start agricultural business farms, and financial support to start the business venture for those who complete the programs.

To retain youths in the sector, they can be supported and guided to start farms and continue farming activities. To acquire the finance required to start their business, these young ones who finish their training programs can be referred to use the government small business grant opportunities and loans provided by MoFA and other donor agencies to

begin farming activities that prioritize youths when giving these funding opportunities. In addition, importance can be given to off-farm agricultural activities such as agricultural office jobs, laboratory jobs, etc., to those not interested in on-farm duties.

Certain crops require increasing production to meet import targets and additional labor, so there is a demand for more farmers, which is an opportunity for young people to invest in the sector to earn an income. The high share of the young residing in rural island communities with lower economic activities and high unemployment rates can also be addressed by training and building youths to start farming based on the region-specific optimal crops. For example, the regions where it needs to choose the growth of cucumber and melon as their optimal yield can target youths to start up technology-integrated farming methods by building their capacity and supporting them to acquire finance and start the business. Besides with proper recruitment and retention strategies the AES officers can encourage and ensure these young farmers produce quality products that assure a guaranteed market and income.

The research findings on breaking the gender disparity issue and empowering women farmers in the agricultural sector are as follows. Most female youths who finish schooling in rural farm communities travel to nearby resorts for job opportunities. Eventually, they have to come back home as they cannot look after their kids once they start their own families. Hence, this disconnects the women from taking part in economic activities. This is, in turn, an excellent opportunity to approach these young women farmers with educational training opportunities to start their own farm business.

Along with the help of AES officers, these women farmers can reach possible market points and scale up their businesses. Adopting technology-based farming methods with appropriate tools and equipment will further empower women to be part of the agricultural sector. It will reduce intense labor activities and allow them to give time for their families and house chores. This will empower the women farmers economically by enabling them to influence decision-making regarding agricultural sector development.

Developing and empowering women farmers and alleviating them from menial agricultural jobs must also focus on women farmers with lower educational backgrounds. To push these women farmers into successful farming activities, videos on preparing farming land areas, sowing, cultivation, pollination, and harvesting techniques can be designed and shared with them through the mobile applications. Voice clips on essential techniques to follow when harvesting and packing fruits and vegetables with demonstrations can be shared too. This will provide an inclusive system where women farmers, regardless of their education and skill background, can actively participate in farming activities and earn an income without depending on their male partners. Ways to maintain the farm accounts and information on when to invest and how to invest will further support these female farmers. It will help them to run their farm activities where they make the decisions and benefit the income solely.

In addition, women farmers can also be supported to form community of female farmers groups where they share successful farming patterns and support each other by ICT learning from one another. This includes techniques for enhancing production, logistical routes, possible market information, and cost-effective strategies for managing farm activities. When women farmers form groups and produce as a group, it helps them become the continuous suppliers of resort markets. In addition, these large business resort chains also have the initiative to develop and scale up women and their economic activities. Hence, supporting the women farmers to form and produce as a farming group will help them reduce transport costs and establish a strong market connection. Thus, it could also open opportunities for these women farmer groups to further move up and feel more confident in the farming sector.

Investing in technology-based farming methods to increase the yields of certain crops that are difficult to grow in the Maldivian soil and climatic condition prevents the misuse of finance and increase the profit the farmer gains, strengthening the farmers' economic sustainability. This also socially empowers women to carry out farming activities without depending on male farmers or the middleman, as through the text

messages and GOVAAN app, women can access the information when required and get support in planning their farm activities. The recommendation to integrate youths into the agricultural sector through training programs and by giving them financial support to start farm businesses strengthens the island communities economically and socially, reducing the unemployment rate and bringing more economic activities to these communities.

These steps are management measures that improve the agricultural activities of the contract farmers, which leads to attaining the economic, social, and environmental sustainability of the family farming communities in the Maldives. This way, the maximum amount of production is adjusted to the external environment. In other words, these recommendations and suggestions improve the management of the contract farming model of AgroNAT by allocating scarce resources to provide food security and develop sustainable agriculture.

Conclusions to Chapter 3

1. Proper farm management of natural resources is crucial for development of sustainable agriculture as it allows to address economic, social and environmental challenges of farming in the Maldives. The study revealed that available resources, such as land and labor, are not rationally utilized to produce quality products and meet the country's requirements caused by the fact that over the past 15 years the Maldivian population doubled. More than 90% of the food used for local and resort consumption is imported, showing the country's high import dependency that endangers the national food and nutrition security. In order to provide long-term productivity small family farmers who participate in the AgroNAT contract farming should redistribute their lands under locally grown crops which fit regional climatic and soil conditions to improve own well-being and fulfill national goals of encouraging sustainable agriculture and food security.

2. The research outcome on farming optimization concerned AgroNAT registered contract farmers from three regions where they grow heavily imported crops such as

pumpkin, banana, watermelon, butternut, cucumber, papaya, melon, brinjal, sponge gourd. The model considered restrictions on regional agricultural lands, financial limits to production expenditures covered by AgroNAT, local input costs and yields, as well as minimal and maximal harvests per every crop. The model criteria calculated the total farmers' income and AgroNAT profit. The found optimal production plans narrowed down regional specialization in growing fruits and vegetables. 7 crops were redistributed to the regions which can provide their most effective production. Bananas were recommended to be grown in regions 1 and 3, while cucumber should be placed among all three regions. With these optimal plans implemented, region 3 and 2 may reduce their input costs by 7% and 43%. They would also increase the farmers' total income by 59%, reduce the AgroNAT's expenses by 52%, and double harvests of banana, watermelon, butternut, and melon. It means that with production optimization, improved farm management of natural resources results in amplifying Maldivian food security and elevating welfare of the local small family farmers.

3. Improved management of agricultural services in farming implies that AES officers need to be developed in terms of relevant knowledge and appropriate skills which should be conveyed to small family farmers for providing food security and fostering sustainable agriculture in the Maldives. The online study on 20 AES officers involved in AgroNAT contract farming revealed that 80% of them are males and 40% have only secondary education demonstrating poor professionalism and qualifications partly compensated by regular training attended by 90% of the AES officers. They appeared to be the least aware of leadership, supervision, administrative management issues, agricultural entrepreneurship, sustainable farming methods, innovative agricultural technologies. The AES officers firmly believe in the demand-driven consulting approach that caters farmers' practical requests. The AES officers' perception of their mission was mostly about increasing agricultural production. However, they admitted being passive in promoting gender equity, improving rural livelihoods, reducing poverty and providing rural development.

4. In order to enhance efficiency and effectiveness of the Maldivian family farmers AES officers must adopt holistic approach to supporting family farming communities. It means that the provided consulting should encompass: farm activity planning, such as allocation of land area, choosing crops, distributing expenditures, selecting right time and weather conditions; field management, focused on sowing, cultivation, dealing with plant pests and diseases; harvesting, in particular pre- and post-harvest management, packing and handling; market challenges, which are about reaching the market and earning a profit from selling the yielded crops. The shared farming recommendations need to be region-specific and consistent with the regional beneficial crops found by the optimization production model. For this reason, the AES officers in region 1 should be competent in the whole cycle of growing, harvesting and marketing banana, cucumber, papaya, melon, and sponge gourd. The AES officers in region 2 ought to accumulate knowledge and skills about producing butternut and cucumber. The predominant qualifications of the AES officers in region 3 must be linked to growing, harvesting and trading pumpkin, banana, watermelon, cucumber, and brinjal.

5. Labor force development through Information and Communication Technology is invaluable with regard to empowering small family farmers to gain contemporary knowledge and skills. In view of the remoteness of rural farming communities in the Maldives, mobile tools and apps may be a major means to deliver agriculture-related data since electronic media play an important role in the adoption of new farming technologies. The conducted statistical analysis showed that gender and age don’t influence farmers’ access to mobile phones and acquired digital skills. Therefore, sharing urgent agricultural information and addressing farmers’ concerns can be provided through text messages, voice clips, photos, and videos on technological topics, crisis management advice, weather forecasts, and market issues. In addition, a mobile application GOVAAN developed by AgroNAT lets assist contract farmers from the planning stage to the point where they receive the payment for their harvests. A quarter of small family farmers who have no digital access need special credit schemes to provide them with affordable smartphones

which are necessary for aligning educational level and increasing effectiveness of agricultural activities among farming communities.

6. Along with the digital support, AES officers should consult small family farmers in person in the fields. For that to happen AES officers must follow an optimal one-cycle route to save time and money while visiting even the remotest farming communities. The conducted model calculations found that it would take AES officers at least 13 hours and 45 minutes to travel between the 8 largest islands participating in contract farming when assistance and personal presence are necessary to carry out agricultural activities or tackle crop-specific issues.

Both online and personal AES consultations are especially beneficial as means to support the women farmers with farming knowledge, financial and management skills facilitating their farm decision-making. It makes possible empower the rural female farmers and address gender disparity observed in the Maldivian agriculture regarding land ownership and inequality in the credit market. The performed research enables to conclude that the target development of sustainable agriculture in the Maldives also depends on recruitment and retention of energetic young farmers to integrate farming technologies and amplify efficiency and effectiveness of farming activities. It should be based on providing training and skill-building programs which improve image of agriculture and its perception by young people to think of farming activities as a viable career option.

The scientific results of Chapter 3 are published by the author in [1], [4], [10], [11].

CONCLUSIONS AND RECOMMENDATIONS

The dissertation study substantiated the theoretical and methodical principles of family farms management through a contract farming model to attain production optimization and sustainability in relation to the food and nutrition security in the Maldives The obtained results of the scientific research make it possible to form the following conclusions:

1. Family farming is a prevalent global agricultural model, which relies on family members for labor and entails managing the entire enterprise while bearing the associated risks. This form of farming is pivotal for rural development, poverty alleviation, and ensuring nutrition security. In economies ranging from developing to developed nations, family farms play a crucial role by contributing to food production, creating employment opportunities, and fostering income generation within rural areas. Taking into account the common features and characteristics, small family farming in the Maldives is typically performed on less than two hectares of land and is focused on providing self-consumption due to input inefficiencies and limited investments. By addressing the world hunger and malnutrition family farming is a driving force to achieve the United Nations Sustainable Development Goals which combine economic, social, and environmental agricultural aspects. The Maldivian family farmers are systematically faced with resource scarcity, climate issues, outdated farming methods, and low revenues. It boosts the concept of "sustainable family farming" that implies implementing eco-friendly socially-responsible farming practices bolstered by economically viable rural communities.

2. Contract farming involves specific agreements between producers and buyers, establishing mutual responsibilities between these business partners through Centralized, Nucleus, Multipartite, Intermediary, and Informal models. All of them offer both monetary and non-monetary advantages, supporting farmers with technology, finance, and advice to enhance yields and address market imperfections. Meanwhile, buyers acquire access to farmlands and labor force, reduce risks, and improved their public

image. Contract farming is a promising way designed for increasing effectiveness and efficiency in farm management. The Centralized contract farming model launched by the state Agro National Corporation holds the potential to diminish country's dependency on food imports and amplify Maldivian agriculture by sharing cutting-edge technologies, supplying inputs, ensuring credits and loans, and fostering produce sales from family farmers who cooperate with AgroNAT.

3. Farm management is about decision-making applied to farm activities with limited production resources in the context of providing food security and prosperity for rural communities. Farm management functions embrace planning, arranging, coordinating, monitoring and controlling to ensure profitable harvests consistent with principles of sustainable agriculture. The succession and competitiveness of family farms depend on advanced farm management concerning specific economic, social and ecological challenges observed in contract farming in the Maldives. Management consulting is a workable tool to generate strategic plans and seize new opportunities to cover the capacity gaps that hinder to fulfil farming goals. Combining management consulting with agricultural extension services will ensure complex professional customized support of family farms in allocating land, labor and capital to harvest more crops while being engaged in sustainable development. The AES officers skilled in management consulting will be able to tackle economic, social, and environmental challenges unique to the Maldivian agriculture, empowering farmers with advanced techniques and methods to bolster rural food security and national welfare.

4. The agricultural sector in the Maldives contributes only 5% to the national GDP, which is overshadowed by the dominant tourism industry. Farming mainly occurs in dispersed and undeveloped island communities, constituting 60% of the population where officially only 10% are employed in agriculture due to subsistent farming in rural areas. The rapid population growth has led to an increased food demand and heavy reliance on food imports. Recent natural disasters and global shocks like the Covid-19 pandemic have exposed food insecurity, prompting government initiatives to support vulnerable small-

family farmers faced with limited suitable agricultural lands, insufficient water supplies for quality harvests, and a lack of awareness about advanced farming technologies. Addressing these challenges requires a complex approach encompassing economic, social, and environmental dimensions about rational use of natural resources, agricultural consulting services, and enhancing the labor force, especially involving underrated female and potential young farmers. This holistic strategy is bound to bring tangible benefits on the way to sustainable family farming in the Maldives.

5. The research study concluded that the PESTLE analysis is a workable contemporary tool which enables us to assess and track influential Political, Economic, Social, Technological, Legal, and Environmental factors that determine farming surroundings and shape decision-making in farm management. With this approach small family farmers can evaluate miscellaneous agribusiness scenarios, adjust to risks, and adapt to beneficial opportunities and challenging threats. The PESTLE analysis applied to the Maldivian agriculture unveiled that the unimplemented National Strategic Farming Plan, irrelevant land laws, undeveloped immigration and import regulations, inadequate insurance procedures have negative political and legal effects on family farming. The hampering economic impact manifests itself through fluctuating inflation, budget deficits, limited credit access, and high unemployment in the rural areas. Aging farmers, gender disparities, and inadequate agricultural education are the most influential social factors affecting the Maldivian agriculture. The most critical technological aspects which hinder progress in farming are lack of IT skills and resistance to innovations. Poor soil quality, water scarcity, natural disasters, and extreme weather conditions are crucial environmental factors that impede agricultural sustainability.

6. The study concludes that the Maldivian agricultural landscape consists of five regions, with AgroNAT contract farming is inactive in two regions due to land tenure issues. At present AgroNAT unites around 500 small family farmers across 14 islands to reduce crop imports by 50% by 2023. Focusing on three regions reliant on agriculture for income and sustenance, AgroNAT’s contract farming model maintains free training and

consulting, aids farmers with seeds, fertilizers, and pesticides, supports in harvesting, assists in trading. Informal interviews and discussions involving 1200 farmers in the explored three regions highlighted noticeable similarities and remarkable differences concerning farmland scarcity and land tenure insecurity, shares of local female and young farmers, finance and market accessibility, supplies of inputs, and climatic instability which are essential for advancing management of contract family farming in the Maldives.

7. The research study revealed that family farmers in the Maldives tend to misuse available land and labor resources that result in increasing national dependency on food imports and dangerous nutrition insecurity. Thus, it is recommended to improve farm management via production optimization encouraging the small family farmers involved in the AgroNAT contract farming to allocate their land for locally suitable crops to enhance productivity, elevate own welfare, and promote sustainable agriculture. The offered model incorporated nine heavily imported fruits and vegetables whose harvests were restricted by regional input costs and yields and had to maximize model criteria related to the total farmers' income and AgroNAT profit. The calculated optimal production plans substantiated narrowed regional specialization in growing crops that allows to double harvests of the most demanded banana, watermelon, butternut, and melon, reduce production expenditures by up to 43%, decrease AgroNAT's expenses by 52%, and raise farmers' income by 59%, i.e. significantly amplify effectiveness and efficiency of contract farming in the Maldives.

8. The research findings comprising 20 AES officers engaged in the AgroNAT contract farming revealed that they preferred demand-driven consulting to address practical farmers' needs mainly linked to boosting agricultural production. Since 80% of the AES officers were male and 40% possessed only secondary education, they acknowledged shortcomings in promoting gender equity, farmers' livelihood improvement, poverty reduction, and rural development. This emphasized the importance of training knowledgeable and skilled AES officers who can cater requests of small family farmers, fostering food security and sustainable agriculture. Thus, the research

recommendations suggest that AES officers should convey region-specific advice on farm planning, field management, harvesting, and market strategies tailored to crops identified by the optimization production model. Besides, the study outcomes persuade that the AES officers need to acquire proficiency in leadership, supervision, administrative management issues, agricultural entrepreneurship, sustainable farming methods, and innovative agricultural technologies whose absence deteriorates family farms' performance and slows down improvements of contract farming in the Maldives.

9. Labor force development via Information and Communication Technology (ICT) plays a crucial role in empowering small family farmers by equipping them with contemporary knowledge. The conducted statistical analysis made it possible to infer that factors like gender and age do not impact access to mobile phones and digital skills of family farmers in the Maldives. Given the remote nature of these rural communities, the study highlights the importance of utilizing mobile tools and online apps for implementing an ICT-integrated approach to share relevant agricultural information through various media formats, including text messages, voice clips, photos, and videos, covering topics like farming technologies, crisis management, weather forecasts, and market issues. Along with the digital support, small family farmers should get in-person consultations with the AES officers in the fields. While engaged with the most remote island communities, the AES officers must follow the optimal one-cycle route to save time and costs as it was recommended by the study calculations. The research concluded that offered online and personal AES consultations are especially beneficial to incentivize female and young farmers' activities to adopt farming as a source of viable income and enlarge their contribution to sustainable agriculture and food security in the Maldives.

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APPENDIX A.

CERTIFICATES ON THE IMPLEMENTATION OF RESEARCH RESULTS

بسم الله الرحمن الرحيم

agro NATIONAL CORPORATION

CERTIFICATE

issued to Nadhiya Abdulla

on the implementation of the scientific research results

Developed author's offers regarding improvements of contract farming management can be used by AgroNat Corporation and demonstrate a positive impact on efficiency and produce quality when applied to family farming activities in L. Isdhoo, L. Kalaidhoo, L. Gan, L. Fonadhoo, Ha. Kelaa, Ha. Baarah, Hdh. Nolhivaranfaru, Hdh. Nolhivaran, Hdh. Vaikaradhoo in the Republic of Maldives.

1. The recommended methodical approach to training AES officers on how to implement sustainable region-specific technologies of farming to foster rural livelihood and food security are especially beneficial when holding meetings on developing qualifications of consulting staff (https://doi.org/10.31521/modecon.V35(2022)-01).

2. The proposed organizational ways of providing contemporary agricultural skills and practices (https://doi.org/10.32702/2306-6792.2023.3-4.33) contributed to engaging and encouraging young and female farmers to participate in contract farming. It ensures their stable incomes and harvests owing to ICT advice and personal help from AgroNat employees who can properly control and timely monitor agricultural dynamics in their areas of responsibility.

3. The calculated plans of allocation farmlands (https://doi.org/10.5281/zenodo. 7620892) are at the stage of implementation in major family farms which operate under AgroNat contract and are expected to decrease farming expenditures by over 10% and raise quantity of harvested crops by over 20% by means of optimal distribution of available resources and inputs.

Assistant General Manager

Farouq Ahmed

AGRO NATIONAL CORPORATION PVT LTD C03242020 REP OF MALDIVES

e-mail: Farouq.ahmed@agronational.mv

19 September 2023

Continuation of Appendix A

Дніпропетровська обласна громадська організація
"Сільськогосподарська консультаційна служба"

49600, м. Дніпропетровськ, вул. Комсомольська, 52, офіс 338 тел. (0562) 31-42-61, тел./факс (0562) 31-42-60

Certificate
issued to Nadhiya Abdulla
on implementing results of scientific research on the topic
"Improving contract farming for family farms management in the context of agriculture sustainable development in the Republic of Maldives."

Implementing economic development projects for family farms in Ukraine, specialists of the Dnipropetrovsk Agricultural Advisory Service, NGO have the experience in comprehensive analysis of family farming models in different countries. The research results presented by Nadhiya Abdulla in her thesis were discussed in working groups of DAAS and considered as valuable for implementation.

In particular, the scientific results (https://doi.org/10.32702/2306-6792.2023.7-8.124 & https://doi.org/10.5281/zenodo.7620892) proposed by Nadhiya Abdulla have practical value in the conditions of Ukraine coursed by the war aggression of russia against Ukraine, challenges connected with the water availability, reducing the land available for agriculture because the temporary occupation, contamination, mining.

These findings are recommended for implementation in Agricultural Advisory Service, NGO (Dnipro, Ukraine) for the combined training of consultants-advisers to improve their qualifications through mastering innovative technologies of sustainable cultivation of crops, determined by the production optimization model, most adapted to the regional operation conditions of small family farms, and the dissemination of contemporary methods and techniques of agricultural management to improve the farmers' welfare and ensure food security of Ukraine.

September 15, 2023. **M. Maksymov**

Continuation of Appendix A

БІЗНЕС МЕРЕЖА СІЛЬСЬКИХ ЖІНОК
Tel: +380676760692
Facebook: @ukrainian.rural.women.business.network

September 15, 2023.

Certificate
issued to Nadhiya Abdulla
on the implementation of the scientific results of her dissertation
"Improving contract farming for family farms management in the context of agriculture sustainable development in the Republic of Maldives."

Rural Women Business Network's mission is to empower rural women by knowledge, information, networking, and resource to change their life for sustainable development of family farms, rural communities and Agriculture. The gender inequality is the global challenge, and experience of family farms in the Maldives in its solving as valuable as the experience of any country.

Nadhiya Abdulla had presented her scientific findings and practical proposal to the RWBN's Board and her analysis and general proposals for overcoming gender disparity in family farming (https://doi.org/10.31521/modecon.V35(2022)-01 and https://doi.org/10.32702/2306-6792.2023.3-4.33) were high evaluated and accepted for adaptation and use in the Non-Governmental Organization Rural Women Business Network (L'viv, Ukraine). The recommended organizational and methodical approaches to conducting surveys and providing consultations of female farmers online and at personal meetings have essential practical significance for further maximum realization of personal production potential and sustainable agriculture development in Ukraine.

President Sofia BURTAK

ГРОМАДСЬКА СПІЛКА "БІЗНЕС МЕРЕЖА СІЛЬСЬКИХ ЖІНОК" І.К. 44155726 УКРАЇНА

Continuation of Appendix A

Міністерство освіти і науки України
ДНІПРОВСЬКИЙ ДЕРЖАВНИЙ АГРАРНО-
ЕКОНОМІЧНИЙ УНІВЕРСИТЕТ

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м. Дніпро, вул. Сергія Єфремова, 25,
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Ministry of Education and Science of Ukraine
DNIPRO STATE AGRARIAN
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11.09.2023 № 16-24-4669

на № _____

To whom it may concern

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Hereby we certify,

the methodical results of the PhD research "Improving contract farming for family farms management in the context of agriculture sustainable development in the Republic of Maldives", performed by a citizen of the Maldives, **Abdulla Nadhiya,** a student of higher education at the third (educational and scientific) level, majoring in 073 Management, ERP Management, have been implemented as educational and methodological materials for teaching the educational components "Management Consulting and Advisory Activities", "Project Management" and "International Economy" at the Department of Management, Public Management and Administration, Faculty of Management and Marketing, Dnipro State Agrarian and Economic University.

Rector **Anatolii KOBETS**

Stamp