Data Collection Survey against Forest Fires on Amazon Basin and Southern African Areas (Final Report)

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Japan International Cooperation Agency (JICA)

Japan Forest Technology Association
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Contents

Attached documents' datas are not disclosed.

General

Abbreviation	English (Spanish)	Japanese
ACTO	Amazonian Cooperation Treaty Organization	アマゾン協力条約機構
ACEER	Amazon Center for Environmental Education and Research	アマゾン環境教育・研究センター
AICS	Agenzia italiana per la cooperazione allo sviluppo	イタリア開発協力庁
ANP	Protected Natural Area (Áreas Naturais Protegidas)	自然保護区
BID	Inter-American Development Bank (Banco Interamericano de Desarrollo)	米州開発銀行
BOP	Base of the (economic) Pyramid	低所得貧困層
COSUDE	Swiss Agency for Development and Cooperation （Agencia Suiza para el Desarrollo y la Cooperación)	スイス開発協力庁
CAF	Development Bank of Latin America (CAF-Banco de Desarrollo de América Latina)	ラテンアメリカ開発銀行
FAO	Food and Agriculture Organization	国際連合食料農業機構
FEMA	Federal Emergency Management Agency	米国連邦危機管理庁
GCF	Green Climate Fund	緑の気候基金
GDP	Gross Domestic Product	国内総生産
GEF	Global Environment Facility	地球環境ファシリティ
GFMC	Global Fire Monitoring Center	世界火災監視センター
GIS	Geographic Information System	地理情報システム
GIZ	German Association for International Cooperation	ドイツ国際協力公社
GMBH	Gordon and Betty Moore Foundation	ゴードン・アンド・ベティ・ムーア財団
ICS	Incident Command System	現場指揮システム
ICT	Information and Communication Technology	情報通信技術
IFM	Integrated Fire Management	統合的火災管理
IGBP	International Geosphere Biosphere Programme	地球圏・生物圏国際協同研究計画
ITTO	International Tropical Timber Organization	国際熱帯木材機構
JAXA	Japan Aerospace Exploration Agency	宇宙航空研究開発機構
JETRO	Japan External Trade Organization	日本貿易振興機構
JICA	Japan International Cooperation Agency	国際協力機構
JOFCA	Japan Overseas Forestry Consultants Associate	海外林業コンサルタンツ協会
KfW	Kreditanstalt für Wiederaufbau	ドイツ復興金融公庫
LANDSAT	Land Satellite	ランドサット(地球観測衛星)
LULUCF	Land-use, Land-use Change and Forestry	土地利用、土地利用変化および林業

Abbreviation	English (Spanish)	Japanese
MODIS	Moderate Resolution Imaging Spectroradiometer	中分解能撮像分光放射計
NASA	National Aeronautics and Space Agency	米国航空宇宙局
NGO	Non-Government Organaization	非政府組織
NORAD	Norwegian Agency for Development Cooperation	ノルウェー開発協力庁
OAPN	National Parks Autonomous Agency (Organismo Autónomo de Parques Nacionales)	スペイン国立公園自治庁
OSM	Open Street Map	オープンストリートマップ
REDD＋	Reducing Emissions from Deforestation and Degradation in Developing countries	開発途上国における森林減少・劣化等に由来する排出の削減等
ROF	Rules of Organization and Functions	組織分掌規定
SAP	Strategic Action Program	戦略的行動計画
SATREPS	Science and Technology Research Partnership for Sustainable Development	科学技術協力
UN	United Nations	国際連合
UNDP	United Nations Development Programme	国際連合開発計画
UNOPS	United Nations Office for Project Services	国際連合プロジェクトサービス機関
USAID	United States Agency for International Development	米国国際開発庁
USFS	United States Forest Service	米国森林局
WB	World Bank	世界銀行
WRI	World Resources Institute	世界資源研究所
WWF	World Wide Fund for Nature	世界自然保護基金

Peru

Abbreviation	English (Spanish)	Japanese
ACCA	Association for the Conservation of the Amazon Watershed (Asociación para la Conservación de la Cuenca Amazónica)	アマゾン流域保全協会
AECID	Spanish Agency for International Development Cooperation (Agencia Española de Cooperación Internacional para el Desarrollo)	スペイン国際開発庁
APP	Public-Private Partnership (Asociación Público Privada)	官民パートナーシップ
ARA	Regional Environmental Authority	州環境局

Abbreviation	English (Spanish)	Japanese
	(Autoridad Regional Ambiental)	
ARAU	Regional Environmental Authority of Ucayali (Autoridad Regional Ambiental de Ucayali)	ウカヤリ州環境局
ARFFS	Regional Forestry and Wildlife Authority (Autoridad Regional Forestal y de Fauna Silvestre)	州森林･野生動物局
BCRP	Central Reserve Bank of Peru (Banco Central de Reserva del Perú)	ペルー中央準備銀行
CAS	Administrative Service Contract (Contrato de Administrativo de Servicios)	行政サービス契約
CENEPRED	National Center for Disaster Risk Estimation, Prevention and Reduction （Centro Nacional de Estimación, Prevención y Reducción del Riesgo de Desastres)	国家災害リスク予防研究センター
CEPLAN	National Strategic Planning Center （Centro Nacional de Planeamiento Estratégico)	国家戦略企画センター
CGBVP	General Volunteer Fire brigade of Peru （Cuerpo General de Bomberos Voluntarios del Perú)	全国ボランティア消防団
CIFOR	Center for International Forestry Research （Centro de Investigación Forestal Internacional)	国際林業研究センター
COEN	National Emergency Operations Center（Centro de Operaciones de Emergencia Nacional)	国家緊急オペレーションセンター
COER	Regional Emergency Operations Center（Centro de Operaciones de Emergencia Regional)	州緊急オペレーションセンター
CONAGERD	National Council for Disaster Risk Management （Consejo Nacional de Gestión de Riesgo de Desastres)	国家防災会議
CONDESAN	Consortium for the Sustainable Development of the Andean Ecoregion（Consorcio para el Desarrollo Sostenible de la Ecorregión Andina)	アンデス生態地域持続的開発コンソーシアム
DL	Legislative Decree (Decreto Legislativo)	立法令
DS	Supreme Decree (Decreto Supremo)	大統領令

Abbreviation	English (Spanish)	Japanese
ECOBONA	Regional Program for the Social Management of Andean Forest Ecosystems (Programa Regional para la Gestión Social de Ecosistemas Forestales Andinos)	アンデス森林生態系の社会的管理のための州プログラム
FCPF	Forest Carbon Partnership Facility	森林炭素パートナーシップファシリティ
FIP	Forest Investment Program	森林投資プログラム
FONCOR	Regional Compensation Fund (Fondo de Compensacción Regional)	地域補償基金
GBF	Forest Fire Rangers Service (Guardaparques Bombero Forestal)	保護区警備・消防隊
GRU	Regional Government of Ucayali (Gobierno Regional de Ucayali)	ウカヤリ州地方政府
GORE	Regional Government (Gobierno Regional)	州政府
IGN	National Geographic Institute (Instituto Geográfico Nacional)	国家地理庁
IGP	Peruvian Geophysical Institute (Instituto Geofísico del Perú)	環境省 ペルー地球物理庁
INBP	National Fire Department of Peru (Intendencia Nacional de Bomberos del Perú)	国家消防局
INDECI	National Institute of Civil Defense (Instituto Nacional de Defensa Civil)	国家防災庁
INEI	National Institute of Statistics and Informatics (Instituto Nacional de Estadística e Informática)	国家統計情報庁
MEF	Ministry of Economy and Finance (Ministerio de Economía y Finanzas)	経済・財務省
MIDAGRI	Ministry of Development, Agriculture and Irrigation (Ministerio de Desarrollo Agrario y Riego)	農業灌漑開発省
MINAM	Ministry of Environment (Ministerio del Ambiente)	環境省
MINDEF	Ministry of Defense (Ministerio de Defensa)	防衛省
MININTER	Ministry of the Interior (Ministerio del Interior)	内務省
MPFN	Public Prosecutor's Office (Ministerio Público Fiscalía de la Nación)	検察庁
OTCA	Amazon Cooperation Treaty Organization (Organización del Tratado de Cooperación Amazónica)	アマゾン協力条約機構
PCM	Presidency of the Council of Ministers (Presidencia del Consejo de Ministros)	首相府

Abbreviation	English (Spanish)	Japanese
PLANAGERD	National Disaster Risk Management Plan (Plan Nacional de Gestión del Riesgo de Desastres)	国家災害リスク管理計画
PPRRIF	Prevention and Risk reduction Forest Fires Plan (Plan de Prevención y Reducción de Riesgos Incendios Forestales)	森林火災リスク予防・低減計画
SENAMHI	National Service of Meteorology and Hydrology of Peru (Servicio Nacional de Meteorología e Hidrología del Perú)	環境省 国家気象・水文局
SERFOR	National Forest and Wildlife Service (Servicio Nacional Forestal y de Fauna Silvestre)	農業灌漑省 国家森林野生動物局
SERNANP	National Service of Natural Protected Areas (Servicio Nacional de Areas Naturales Protegidas por el Estado)	環境省 国家保護区管理局
SGRD	Secretariat of Disaster Risk Management （Secretaría de Gestión del Riesgo de Desastres)	首相府内災害リスク管理事務局
SINADECI	National Civil Defense System (Sistema Nacional de Defensa Civil)	国家災害リスク管理制度（旧）
SINAGERD	National Disaster Risk Management System (Sistema Nacional de Gestión del Riesgo de Desastres)	国家災害リスク管理システム
SINANPE	National System of Natural Protected Areas (Sistema Nacional de Areas Naturales Protegidas por el Estado)	国家自然保護地域システム
SISFOR	Geographic Information System for Forestry and Wildlife Supervisions (Sistema de Información Geográfica de Supervisiones Forestales y de Fauna Silvestre)	森林･野生動物監督地理情報システム
SNIFFS	National System of Forest and Wildlife Information (Sistema Nacional de Información Forestal y de Fauna Silvestre)	国家森林･野生動物情報システム
UNALM	National Agricultural University La Molina (Universidad Nacional Agraria La Molina)	ラモリーナ農業大学

Brasil

Abbreviation	English (Spanish)	Japanese
ABIOVE	Brazilian Association of Vegetable Oil Industries	ブラジル植物油産業協会

Abbreviation	English (Spanish)	Japanese
	(Associação Brasileira das Indústrias de Óleos Vegetais)	
ANA	National Water Agency (Agência Nacional de Águas)	国家水資源庁
BEA	Environmental Emergency Battalion (Batalhão de Emergência Ambientais)	環境緊急部隊
CEMADEN	National Center of Monitoring and Warning of Natural Disasters (Centro Nacional de Monitoramento e Alertas de Desastres Naturais)	国家自然災害モニタリング・警報センター
CGF	Fire Management Committee (Comitê de Gestão do Fogo)	火災管理委員会
CIMAN	Integrated Multiagency Operational Coordination Centre (Centro Integrado Multiagências de Coordenação Operacional)	全国多機関統合的運営調整センター
CIMAN- MT	Integrated Multiagency Operational Coordination Centre-Mato Grosso (Centro Integrado Multiagências de Coordenação Operacional de Mato Grosso)	マットグロッソ州多機関統合的運営調整センター
CNPq	National Council for Scientific and Technological (Conselho Nacional de Desenvolvimento Científico e Tecnológico)	国家科学技術・開発委員会
COIAB	Coordination of Indigenous Organizations of the Brazilian Amazon (Coordenação das Organizações Indígenas da Amazônia Brasileira)	ブラジルアマゾンインディオ組織連合
COMDEMA	Municipal Environment Council (Conselho Municipal De Meio Ambiente)	市環境審議会
CONAMA	National Environment Council (Conselho Nacional do Meio Ambiente)	国家環境審議会
CPCIF	Forest Fire Prevention and Combat Course (Curso de Prevenção e Combate aos Incêndios Florestais)	森林火災予防・森林火災対策の研修コース
FUNAI	National Indian Foundation (Fundación Nacional del Indio (Brasil))	国立先住民保護財団
IAI	Inter-American Institute for Global Change Research	地球変動に関するインター・アメリカ研究機構
IBAMA	Brazilian Institute for the Environment (Instituto Brasileiro do Meio Ambiente e dos Recursos Naturais Renováveis)	ブラジル環境・再生可能天然資源院
IBGE	Brazilian Institute of Geography and Statistics (Instituto Brasileiro de Geografia e Estatistica)	ブラジル地理統計院

Abbreviation	English (Spanish)	Japanese
ICMBIO	Chico Mendes Institute for Biodiversity Conservation (Instituto Chico Mendes de Conservação da Biodiversidade)	シコ・メンデス生物多様性保全院
ICV	Life Center Institute (Instituto Centro de Vida)	生活センター研究所
IMAZON	Instituto do Homem e Meio Ambiente da Amazônia (Institute of People and the Environment of the Amazon)	人々と環境のためのアマゾン研究所
INCRA	National Institute for Colonization and Agrarian Reform (Instituto Nacional de Colonização e Reforma Agrária)	国家植民・農地改革院
INPE	National Institute for Space Research (Instituto Nacional de Pesquisas Espaciais)	国立宇宙研究所
IPAM	Amazon Environment Research Institute (Instituto de Pesquisa Ambiental da Amazônia)	アマゾン環境研究所
ISA	Socio-Environmental Institute (Instituto Socio-Ambiental)	社会環境研究所
MAPA	Ministry of Agriculture, Livestock and Supply (Ministério da Agricultura, Pecuária e Abastecimento)	農業畜産食糧供給省
MCTI	Ministry of Science, Technology and Innovation (Ministério da Ciência e Tecnologia e inovação)	科学技術革新省
MD	Ministry of Defence (Ministério da Defesa)	国防省
MDA	Ministry of Agrarian Development (Ministério do Desenvolvimento Agrário)	農地開発省
MMA	Ministry of Environment (Ministério do Meio Ambiente)	環境省
PNMIF	National Politics for Integrated Fire Management (Política Nacional de Manejo Integrado do Fogo)	国家統合的火災管理政策
POTIF	Integrated Plan for the Prevention of Fires and the Fight against Forest Fires in the State of Mato Grosso (Plano de Operações para a Temporada de Incêndios Florestais)	マットグロッソ州における火災予防と森林火災対策に関する総合計画
PPE	Personal Protective Equipment	消防士の個人防具
PREVFOGO	National Center to Prevent and Compat Forest Fires (Centro Nacional de Prevenção e Combate aos Incêndios Florestais)	国家森林火災予防対策センター

Abbreviation	English (Spanish)	Japanese
RAISG	Amazonian Network of Geo-referenced Socio-environmental Information (Red Amazónica de Información Socioambiental Georreferenciada)	アマゾンジオリファレンス社会環境情報ネットワーク
REM-MT	REDD+ Early Movers – Mato Gross	マットグロッソ州 REDD+ 初動プログラム
SCI	Incident Command System (Sistema de Comando de Incidentes)	標準火災監視システム
SCR	System of Regional Accounts （Sistema de Contas Regionais）	地域別会計システム
Sisfogo	National System of Fire Information (Sistema Nacional de Informações sobre Fogo)	国家火災情報システム
SISNAMA	National System of Environmental （Sistema Nacional do Meio Ambiente）	国家環境システム
SNUC	National System of Protected Areas （Sistema Nacional de Unidades de Conservação）	国家保護区システム
TI	Indigenous Territories (Terras Indígenas)	先住民族地域
UFMT	Federal University of Mato Grosso (Universidade Federal de Mato Grosso)	マットグロッソ連邦大学

Bolivia

Abbreviation	English (Spanish)	Japanese
ABT	Land and Forestry Authority (Autoridad de Bosques y Tierra)	全国森林・林地監督庁
APMT	Plurinational Authority of Mother Earth (Autoridad Plurinacional de la Madre Tierra)	マザーアース多民族機関
CEJIS	Center for Legal Studies and Social Research (Centro de Estudios Juridicos e Investigacion Social)	法学・社会調査センター
CIPCA	(Centro de Investigación y Promoción del Campesinado)	農民調査・振興センター
CONARAD	National Council for Risk Reduction and Emergency and Disaster Response (Consejo Nacional de Reducción de Riesgos y Atención de Emergencias)	緊急事態および災害リスク削減と対応のための国家評議会
DGGDF	General Directorate of Forestry Management and Development (Dirección General de Gestión y Desarrollo Forestal)	森林管理・開発管理局

Abbreviation	English (Spanish)	Japanese
ETA	Autonomous Territorial Entities (Entidades Territoriales Autónomas)	自治体行政機関
FAN	Friends of Nature Foundation (Fundación Amigos de la Naturaleza)	自然の友基金
FFAA	Bolivian Armed Forces (Fuerzas Armadas de Bolivia)	ボリビア軍
GFDRR	Global Facility for Disaster Reduction and Recovery	世界減災復興ファシリティ
INE	National Institute of Statistics (Instituto Nacional de Estadistica)	ボリビア国家統計局
INRA	(Instituto Nacional de Reforma Agraria)	土地改革庁
MD	Ministry of Defence (Ministerio de Defensa)	国防省
MMAyA	Ministry of Environment and Water (Ministerio de Medio Ambiente y Agua)	環境水資源省
SAR – FAB	Search and Rescue - Bolivian Air Force (Búsqueda y Rescate - Fuerza Aérea Boliviana)	ボリビア空軍ボランティア団体
SATIF	Early Warning System for Forest Fires (Sistema de Alerta Temprana de Incendios Forestales)	森林火災早期警報システム
SATRIFO	Monitoring and early warning system for forest fire risks (Sistema de monitoreo y alerta temprana de riesgos de incendios forestales)	森林火災リスク早期警報システム
SENAMHI	National Service of Meteorology and Hydrology (Servicio Nacional de Meteorologia e Hidrologia)	国立気象・水文サービス
SERNAP	National Protected Areas Service (Servicio Nacional de Áreas Protegidas)	国家保護地域庁
SIMB	Forest Monitoring and Information System (Sistema de Información y Monitoreo de Bosques)	森林情報監視システム
SINAGER	Integrated Information and Early Warning System for Disaster Risk Management Disaster Risk Management (Sistema Integrado de Información y Alerta para la Gestión de Riesgo de Desastres)	災害リスク管理のための総合的な情報・警戒システム
SISRADE	National System for Risk Reduction and Disaster Attention (Sistema Nacional de Reducción de Riesgos y Atención de Desastres)	リスク軽減と緊急災害対応のための国家システム
SRCMIB	Regulation and Control System for the Integral Management of Forests	森林管理のための規制管理システム

Abbreviation	English (Spanish)	Japanese
	(Sistema de Regulación y Control para el Manejo Integral de Bosques)	
TIPNIS	Indigenous Territory and Isiboro Secure National Park (Territorio Indígena y Parque Nacional Isiboro Secure)	イシボロセキュア国立公園と先住民の領土
VIDECI	Vice Ministry of Civil Defense (Viceministerio Defensa Civil)	市民保護次官室
VMABCCGDF	Vice-Ministry of the Environment, Biodiversity, Climate Change and Forestry Management and Development (Viceministerio de Medio Ambiente, Biodiversidad, Cambios Climáticos y de Gestión y Desarrollo Forestal)	環境・生物多様性・気候変動・森林管理・開発副省
UGR	Risk Managment Unit (Unidad de Gestión de Riesgo)	地方リスク管理機関
UGRF	Forest Risk Management Unit (Unidad de Gestión de Riesgo Forestal)	森林リスク管理機関
UMAIB	Forest Information Monitoring and Analysis Unit (Unidad de Monitoreo y Análisis de Información de Bosques)	森林情報監視分析機関

Location map of the study area (Amazon Basin region)

Location map of the study area (Southern Africa region and KAZA-TFCA)

I. Background of the Study

Forest fires, which are becoming more frequent and larger in scale around the world, are spreading throughout the world, both in developed and developing countries, and are recognized as one of the high-level agendas of the international community.

According to the Global Assessment of Forest Fire Management published by FAO (2006), about 85% of forest fires in South America are of anthropogenic origin. The main anthropogenic activity is the burning associated with the conversion of land from forest to agricultural use, but while low rainfall in the areas of occurrence has traditionally spurred fire spread, 2019 produced the worst conditions on record, despite ample rainfall. The main reason for this is said to be the expansion of the scale of agricultural land development due to a change in Brazilian government policy, suggesting a close relationship between forest fires and government economic policy.

On the other hand, looking at the African continent, the FAO report points out that the continent has a distinct dry and rainy season, and that the ecosystem is maintained by forest fires, The study also points out that the number of fires in African forests has increased because of inappropriate burning outside of the control of the local chiefs. This suggests that forest fires on the African continent are closely related to the ethnicity of the local population, including newcomers, and to local customs and lifestyles.

In the United States and Australia, which are leading countries in forest fire response, it is very difficult to control forest fires once they occur, as seen in recent wildfires. In addition, given the increasing need to clarify the drivers of forest fire, it is necessary to identify forest fire drivers and provide appropriate countermeasures through a combined analysis of macroeconomic perspectives such as national policies, non-forest sectors such as agricultural activities, and cultural anthropological perspectives such as local customs and climatic conditions. It is required to indicate the appropriate countermeasures.

II. Purpose of the Study

Forest fire control can be understood as a series of stages: prevention, detection, fire suppression, and site restoration. The study will be useful for the study of effective integrated fire management. The study will also focus on dry forest areas on two continents where forest fires occur on a large scale and over a wide area and will examine driver measures to prevent major forest fires from occurring, with the aim of considering the possibility of Japan's future support in the context of international support flows.

II.1. Study area

As mentioned above, the study will cover two main areas, Southern Africa and the Amazon Basin. Each of these regions and their respective overviews are described below.

II.1.1. Amazon Basin

The four countries included in the region are Brazil, Peru, Bolivia, and Colombia, and field surveys will be conducted in Brazil, Peru, and Bolivia (see map at the beginning of this report). The Amazon Basin is a vast area of approximately 6.7 million km^2 formed by the Amazon River and its tributaries, which begins in the Andes Mountains and flows eastward, and has the largest tropical rainforest in the world, covering approximately 5.5 million km^2 (2.1 million square miles) Eight countries (Bolivia, Brazil, Colombia, Ecuador, Brazil, Peru, Colombia, Bolivia, and Ecuador are the target countries of this study, and surveys will be conducted in the Amazon River basin and its margins in each country.

II.1.2. Southern Africa

The six countries included in the region are Botswana, Zambia, Angola, Namibia, Zimbabwe, and the Democratic Republic of the Congo, of which Botswana and Zambia will be surveyed in the field.

The project area is located in the Southern Africa region, and the climate is mainly arid to semi-humid. The Kavango Zambezi Transboundary Conservation Area (hereinafter referred to as "KAZA-TFCA") covers an area of 520,000 km^2 and is the largest transboundary protected area in the world. Located in the Okavango - Zambezi River basin, it is characterized by a rich ecosystem of savannas, grasslands, dry forests, and wet forests, as well as a rich fauna. The Democratic Republic of the Congo has the second largest tropical rainforest after the Amazon and has a tropical climate. The direct contribution of these results to forest fire management in KAZA-TFCA, which is being formed as a SADC-JICA forest project, was noted. Therefore, the scope of this study was focused on the KAZA-TFCA.

III. Process of the Study

The initial contract period for this study was from March 25, 2020 to November 30, 2020, and during this contract period, it was planned to conduct field surveys in the Amazon Basin region in Brazil and Bolivia, and in the southern Africa region in Zambia and Botswana.
Meanwhile, the new coronavirus COVID-19 began to spread in earnest in 2020, and lockdowns and other measures were taken in the countries where the field surveys were scheduled to be conducted, so it was decided to extend the contract period multiple times and monitor the situation.
However, the situation did not improve, so the survey method was switched to one that utilized local consultants in the field, and information was collected and surveyed.

Part 1: Study of Fire Causes in the Amazon Basin

1. Investigation of Fire Causes in the Amazon Basin

1.1. Topography

More than half of the Amazon Basin is occupied by tropical rainforest and is also home to the largest freshwater system on earth. As such, it plays a vital role in the global water cycle and carbon cycle, and has an important role in regulating the world's climate. Annual precipitation ranges from about 200 mm/year in the western Andes Mountains region to more than 6,000 mm/year in some areas from central to eastern regions. It is one of the world's richest areas in terms of biodiversity, with more than 30,000 species of plants, 3,000 species of fish, 60 species of reptiles, 35 families of mammals, and 1,800 species of birds. It has a population of about 48.5 million people, and its main economic activities are the extraction of natural, mineral, and forest resources, fishing, agriculture, mining, and small-scale tourism, which affect the quantity and quality of water resources in the Amazon basin (ACTO/SAP 2018)[1] .

The average annual temperature in the Amazon River Basin is around 25 to 28 degrees Celsius, generally hot and humid throughout the year, but divided into a rainy season (December to March) and a dry season (June to September). Annual precipitation is 2200 mm (Coe et al. (2016)[2] , with more than 250 rainy days per year. The vegetation in the Amazon River Basin is generally similar tropical rainforest, but is scientifically divided into 53 ecosystems, which differ significantly from the natural conditions and landscapes of the Andean region to the west and the Cerrado region to the south. The highest number of deforestation and forest fires occur on the margins of the Amazon biome, especially in the transition zone with the Cerrado biome, and the term "arc zone of deforestation" exists in Brazil to refer to them. Most of them are tropical semi-evergreen forests, and they are generally seasonal, with the dry season lasting from around May-June to September-October, and the landscape differs significantly from the wet season. This area has long been the subject of pasture and soybean field conversions.

In the estuary region of the Amazon River, annual rainfall exceeds 3,000 mm. On the other hand, near the Brazilian state of Goias, located in the middle reaches of the Amazon River, annual rainfall decreases to 1,500 to 1,700 mm. In the west, rainfall is distributed relatively evenly throughout the year, with the north receiving the most rainfall in the middle of the year, and the southeast receiving the greatest amount at the end of the year.

1.2. Forest Fire Incidence and Trends

1.2.1. Peru

The largest number of fires since 2001 occurred in 2005, followed by 2007 and 2010, with fire acreage more than double that of other years. In terms of land cover, Evergreen Broadleaf Forests account for about 50%, and Woody Savanna, Savanna and grassland for about 50%. Compared to the Brazilian state of Mato Grosso, the Evergreen Broadleaf Forest is characterized by a larger proportion of fires. In addition, fire frequency is highest in August of the year, followed by September and October at the same level. This is said to be largely due to the fact that fires are set in September and October, when the rainy season begins.

1.2.2. Brazil

Analysis of MODIS/MDC64A1 for the period 2010-2020 for the legal Amazon showed that the average annual forest fire area was 121,076 km2 (±52,506 km2), and that in 2010, 2012,

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[1] http://otca.org/en/project/strategic-action-program-sap/ (2023.02.24)

[2] Coe et al. (2016) The Hydrology and Energy Balance of the Amazon Basin, Interactions Between Biosphere, Atmosphere and Human Land Use in the Amazon Basin, in. Nagy eds. p35-53. https://doi.org/10.1007/978-3-662-49902-3 (2023.02.24)

2015, 2017, and 2020 the average annual forest fire area was found to have been above the average.

Approximately 22.2% ± 3.3% and 10.3% ± 0.9% of the total forest fire area from 2010 to 2020 occurred within indigenous lands and protected areas. Most of the forest fires also occurred in what is known as the "deforestation arc" in the southern part of the legal Amazon. More than 64% of these fires occurred within the states of Mato Grosso (36.6%) and Tocantins (27.9%), followed by Marañón (15.5%) and Hondonia (12.4%). The remaining 7.6% of forest fires occurred in the states of Colima (2.6%), Amazonas (2.1%), Pará (2.0%), Amapa (0.7%) and Acre (0.2%).

In terms of land use type, forest fires occurred mostly in savanna vegetation (30%), grassland (19%), pasture (17%), forest (14%), and soybean cropland (5%).

1.2.3. Bolivia

According to the Food and Agriculture Organization of the United Nations (FAO), deforestation in the Amazon Basin of Bolivia averaged 2,703 km2 per year (1990-2000) and 2,015 km2 per year (2000-2010), but in the most recent period, 2010-2020, the area decreased to 2,252 km2 (0.43% annual decrease) The annual rate of forest loss in the most recent decade was 2,252 km2 (0.43% per year). The annual deforestation rate in the last 10 years is the 9th highest in the world.

The number of fires between 2010 and 2021 averaged about 32,993 per year, although it peaked in 2010 (83,119). More recently, the number of fires exceeded 40,000 in 2019 and 2020, but declined to 34,429 in 2021.

In Bolivia, forest fires in the state of Santa Cruz have become more prominent in the past decade, and the causes are said to include agricultural land expansion. The background is said to be related to weak government regulation of slash-and-burn.

1.2.4. Colombia

Land development through cattle grazing has been reported as the main cause of forest fires in Colombia, which have increased six-fold since the November 24, 2016 FARC-Colombian government peace agreement in the Tinigua-Picachos-Macarena Reserve (Armenteras , Schneider and Dávalos, 2018).

According to the Food and Agriculture Organization of the United Nations (FAO), deforestation in Colombia has decreased on average annually by 2,223 km2 (1990-2000), 1,928 km2 (2000-2010) and 1,666 km2 (2010-2020).

1.3. Forest Fire Drivers

1.3.1. Pertaining to natural phenomena

Among the problems caused by natural factors, those related to natural phenomena include, for example, spontaneous combustion caused by lightning strikes. The Cerrado ecosystem, typical of the Brazilian Midwest, is a semi-arid ecosystem similar to the savanna ecosystems of Africa, characterized by a unique mosaic landscape of different vegetation types, such as grasslands and riparian forests. While natural landscapes are always characterized by some disturbance factor, the most important factor in maintaining the characteristics of the Cerrado ecosystem is fire, which has been occurring regularly since ancient times due to lightning strikes, in addition to natural conditions such as temperature and precipitation. In other words, forest fires are a prerequisite for maintaining the fauna and flora that make up this landscape, which is why some protected areas in the Brazilian Cerrado Zone are maintained by periodic fires.

1.3.2. Climate change-related

In recent years, climate change, global warming, and associated extreme weather events have been reported in many parts of the world. As long as forest fires occur within the natural cycles and resilience described above, ecosystem degradation can be minimized. However, climate change, with its rising temperatures, decreasing precipitation, and drier conditions, will create conditions for more frequent, larger, and longer-lasting forest fires. In particular, prolonged drought-like extremes can severely weaken the ability of ecosystems to withstand the extreme conditions that forest fires can inflict on them. In addition, forest fires that become larger and more prolonged as a result of climate change may exceed the capacity of governments to respond, and countermeasures may be inadequate or inadequate. Thus, climate change is considered an important driver affecting forest fires.

1.3.3. Related to development policy and planning

Many of the forest fires that have become problematic in recent years can be attributed to anthropogenic factors. Anthropogenic factors can be divided into "negative drivers" that lead to more frequent and larger forest fires, and "positive drivers" that work to prevent forest fires from occurring and becoming larger. Understanding both positive and negative drivers and considering countermeasures against them is important when considering forest fire prevention.

Typical of the negative drivers are the policies, institutions, and plans of national and local governments aimed at regional development. For example, if land use conversion from forest to agricultural land is promoted as part of economic policy, it will create an environment prone to deforestation and associated forest fires. In addition, land use planning and development zoning, as well as policies to promote agriculture, forestry, and land development (tax incentives, subsidies, etc.), which act as incentives for residents to change land use, should all be recognized as negative drivers.

1.3.4. Related to environmental policy and planning

On the other hand, government policies, institutions, and plans related to the conservation of forests, nature, water resources, and the environment are positive drivers that prevent forest fires from occurring, becoming larger, and becoming more prolonged. The most important of these are forest-related laws, protected area-related laws, and various environmental regulations. Furthermore, the administrative structures, monitoring and regulatory systems, policing systems, regional centers, budgets, personnel, equipment, and the availability and scale of priority areas for implementing these policies and plans must be recognized as positive drivers to prevent forest fires from occurring and spreading. It is necessary to recognize them as

1.3.5. Related to socioeconomics

Socio-economically related drivers are forest fires caused by human activities, including bonfires, tobacco mismanagement, burning fields and open fires, and arson. While these can be considered direct drivers, it is important to note that they are greatly affected by indirect drivers such as population distribution and dynamics around the area of origin, industrial structure (especially primary industry activities such as agriculture, forestry, and mining), and transportation infrastructure such as roads and railroads.

The Amazon Basin is also dotted with protected areas and settlements established for the purpose of preserving the lives and cultures of indigenous peoples. It is important to note that land use in and around them has different characteristics than in other areas, such as forest fires with traditional slash-and-burn practices, and therefore forest fire drivers have different characteristics than in other areas. Such lands are also characterized by the fact that they are often located deep in the Amazon Basin and other areas that are not easily monitored and policed by the central and local governments, and where firefighting systems are often inadequate, so that when forest fires do occur, the risk of them becoming large is high.

1.4. Regulations, administrative structures, and socioeconomic matters related to forest fires

1.4.1. Peru

In Peru, there is no law or policy-level regulation specifically addressing forest fire, so forest fire response has been conducted in accordance with laws and regulations related to various natural disasters and forest and wildlife conservation, as well as laws and regulations addressing fires in general. However, in response to the recent escalation of forest fire damage, the country's first draft law on forest fires was released as of January 2021. The draft law aims to extend the responsibilities of the National Volunteer Fire Brigade (CGBVP) under the National Fire Service (INBP) to forest fire prevention, monitoring, and management activities. If passed, the draft is expected to serve as the basis for the formulation of policies and plans to combat forest fires in the country, and to improve the implementation environment for forest fire control on a nationwide scale.

1.4.2. Brazil

Brazil classifies its lands into six types based on their natural vegetation and climate: Amazonia, Caatinga, Cerrado, Atlantic Forest (Mata Atlântica), Pampa, and Pantanal. These are called biomes. In addition to this classification, Amazonian zones are designated by law as "legal Amazonias" in order to distinguish the scope of application of various policies, measures, and taxation systems. The Legal Amazon includes nine states (Acre, Amapa, Amazonas, Mato Grosso, Marañón, Pará, Hondonia, Horaima, and Tocantins). As noted above, this report covers all states in the "legal Amazon" as the Amazon Basin, but the Amazon Basin includes four biomes: Amazon, Cerrado, Catinga, and Pantanal.

The Forest Law (No. 4.771), enacted in 1965, is the most comprehensive law related to the conservation and use of forests and also provides for the protection of natural vegetation. Article 27 of the Law restricts the use of fire on forests and other vegetation. It also requires landowners to maintain 80% of the land area in the Amazon and 35% in the Cerrado in its natural state in order to limit development activities. in 1998, the "Fire Code" was further clarified and the regulations and systems for fire use and fire prevention were strengthened. However, the 2012 amendment to the Forest Law clearly stipulates the management standards for the use of fire in forests as a stand-alone provision, while Article 38 lowers the restrictions on land conversion, which can be seen as a substantial deregulation of agricultural land cultivation in forests, and thus threatens previously protected lands. Environmental NGOs and environmentalists have pointed out that this would effectively deregulate agricultural development in the forest, threatening previously protected lands. Indeed, in 2019, the National Institute for Space Research (INPE) reported a 195% increase in forest fires compared to the previous year, and in response, the country's government has issued several 60- to 120-day bans on the use of fire.

1.4.3. Bolivia

Bolivia has been implementing policies since the 1990s to control deforestation by requiring permits for development projects in forests, but there are no legal or policy-level provisions specific to forest fires. In addition, as shown in the table below, the government's stance on forest fire prevention has not always been accompanied by consistency: while prohibiting slash-and-burn, from 2013 to 2019 the government deregulated agricultural activities and land conversion through slash-and-burn, which is also a cause of forest fires.

1.4.4. Colombia

There are few laws in Colombia that focus exclusively on forest fires, and most provide for forest fires within laws and regulations related to natural disasters, forests, and general fires. Examples include the National Risk Management System Law (Law No. 1523), which considers responses before, during, and after the occurrence of various risks, including forest

fires, and the General Forest Law (Law No. 1021), which establishes obligations for forest owners and occupants. As in other countries, there is also a criminal code that establishes sanctions for direct or indirect involvement in forest fire outbreaks.

In contrast to laws and regulations, there are various plans and strategies focused on forest fire preparedness. These focus primarily on actions for forest fire prevention, including the "Educational Strategy for Risk Management Focusing on Forest Fire Prevention," prepared by the Valle del Cauca Regional Autonomous Corporation (CVC), a public corporation at the municipal level. The National Forest Development Plan also provides for agriculture for forest fire prevention.

1.5. Support Needs in Forest Fire Prone Areas

1.5.1. Peru

Peru as a whole experienced an average of 12,438 fire hotspots per year between 2010 and 2021, with the number of forest fires particularly high in the province of Ucayali, which has a large forest area. While there is an urgent need to strengthen countermeasures in the field, interviews revealed that many difficulties are being faced. The challenges recognized by the stakeholders are summarized in theTable 1 .

Table 1 Issues related to forest fire response in Ukayali Oblast

organizations concerned (involved)	issue
State Emergency Operations Center (COER)	There is no provision in the operational jurisdiction regarding forest fires. As a result, the response to forest fires is limited. In addition, the mandate mainly focuses on disaster coordination and is limited in its response to forest fires.
Government of Ukayali Region (GRU)	Legislation is needed to define the role of the Government of Ukayali Region (GRU) in relation to forest fires.
Ucayali State Fire Brigade (CGBVP-Ucayali)	The status of firefighters needs to be guaranteed (institutional improvement). Need to expand funding and equipment for forest fire response.
State Protected Areas Administration (SERNAP)	Need to expand funding and equipment for forest fire response.

Source: Nippon Koei Co.

The above interview results indicate that there are both long-term policy and institutional issues as well as practical issues that need to be addressed in the field in the short to medium term. In terms of policy and institutional issues, it can be pointed out that there is a need to review the consistency of the mandates of each agency and to develop a system to guarantee the status of firefighters. On the other hand, in the short- to medium-term, it can be pointed out that there is a need to support the implementation of forest fire control measures at the field level, including the smooth operation of existing forest fire monitoring and warning systems such as GEO-SERFOR, strengthening the coordination system among stakeholders, and expanding and upgrading funds and equipment.

1.5.2. Brazil

Although the early warning and monitoring system in Mato Grosso is well developed, the interviews revealed that there is a high need for assistance to implement a rapid and appropriate response to fires in the field. In particular, the greatest need is for assistance to enable initial response to control the spread of fire. The following is a summary of assistance needs based on interviews with the National Forest Fire Prevention and Response Center (PREVFOGO).

Strengthen information and communication systems to promote collaboration

The State of Mato Grosso has a large area, including the legal Amazon, and a major challenge is to shorten the time between the identification of the forest fire area and the arrival of the fire brigade. In order to implement a rapid initial response, it is important to strengthen coordination between emergency response offices at the central and local levels, as well as between local emergency response offices and their respective fire departments. It is also essential to establish an information aggregation system to consolidate information from multiple relevant agencies for appropriate judgment and rapid decision making. The State Fire Information System (SISFOGO) is an information aggregation system, but the infrastructure in the state is underdeveloped, the capacity building of the experts operating the system is insufficient, and there are still issues regarding maintenance and updating, etc. Support for the smooth operation of the State Fire Information System (SISFOGO) is particularly needed. Support for the smooth operation of the National Fire Information System (SISFOGO) is especially needed.

Expansion of equipment to enhance initial response capacity in forest fire areas

Frequent updating of firefighters' basic equipment (PPE) and equipment needed for firefighting would be ideal, but is considered impractical due to the high cost of many of these items. In addition, vehicles such as pickup trucks, tractors and motorcycles are essential during fire seasons, but require frequent maintenance, which is currently not adequately done. In addition, helicopters and other vehicles are important for forest firefighting in Mato Grosso State over large areas, such as moving firefighters quickly, evacuating hazardous areas, and transporting large amounts of water, and need to be further expanded.[3]

Strengthen firefighter capacity and educate and train residents

The fire brigade is formed annually during the forest fire season, and its term of office is six months per year. Therefore, since different personnel are hired into the fire brigade each year, it is not expected that firefighters will be able to accumulate knowledge through their experience. In order to conduct effective firefighting activities, training activities need to be conducted on an ongoing basis, as well as training and awareness-raising activities for residents of village communities who handle fire for agricultural, cultural, and traditional purposes from the perspective of fire prevention.

1.5.3. Bolivia

Interviews with stakeholders implementing forest fire response in Santa Cruz County revealed that, in addition to the lack of forest fire training and forest fire prevention policies, the following issues were identified: capacity building of forest fire response personnel, lack of coordination among stakeholders, and inadequate infrastructure for volunteer fire brigades to operate. The following is a summary of the results of the interviews.

Table 2: Challenges Facing Santa Cruz County Forest Fire Response Stakeholders

[3] A policy (PL 4629/20) is being discussed in Brazil for the use of agricultural aircraft to fight forest fires during the agricultural off-season. (Câmara dos Deputados. Agência Câmara de Notícias - CCJ aprova projeto que permite usar aviação agrícola no combate a incêndio florestal. 2021. https://www.camara.leg.br/noticias/803852-ccj-aprova-projeto-que-permite-usar-aviacao-agricola-no-combate-a-incendio-florestal/

organizations concerned (involved)	issue
Bolivian Police	• Firefighter training academy in Tarija needs to be strengthened • There is limited coordination among the military, police, Land Reform Agency (INRA), National Agency for Protected Areas (SERNAP), Local Risk Management Agency (UGR) and village department officials for warning and monitoring.
Santa Cruz County Forest Firefighters	• Need to strengthen personnel assigned to the front lines to deter forest fires • Comprehensive forest fire management and fire protection capacity needs to be strengthened through the formation of forest fire fire brigades • Although the EU, JICA, Canada, France, and others have been approached to provide assistance regarding forest fires, there is no coordination mechanism and only sporadic assistance has been provided.
Santa Cruz Province volunteer organization	• Need to raise awareness among the younger generation and strengthen information dissemination in the event of forest fires
Robore City	• Need to establish a fire station to respond to forest fires and expand equipment and materials to extinguish fires
Entre Rios City	• Forest fires are occurring due to conversion of agricultural and pasture lands by policies to promote agriculture and livestock production.
City of Chiquitano San Jose Local risk management agencies (UGRs)	• Need to expand budget to understand the causes and mechanisms of forest fires
volunteer fire brigade	• Insufficient material support for the volunteer fire companies, making it impossible for them to conduct sufficient activities. There is also a lack of fuel for vehicles to travel to fire areas.

Source: Nippon Koei Co. (based on interviews during the field survey)

1.6. Cooperation with other donors for forest fires

1.6.1. Peru

The number of donor-supported projects specifically addressing forest fires has increased since 2019, when forest fires in the Amazon Basin became a global issue. The projects are mainly aimed at sustainable development policies in forest areas and capacity building of stakeholders to deal with forest fires. On the other hand, there are also projects related to forest landscape restoration, emissions reduction, sustainable development, and disaster risk management, taking into account climate change impacts.

The main aid projects related to forest fires in Peru over the past 10 years, including donors, aid amounts, aid duration and main activities, are organized in theTable .

Table 3 Regional Cooperation Projects Related to Forest Fires (Peru)

Project Name/Abbreviation	Target Area	donor	Aid Amount (USD) period of assistance	Purpose and Major Activities	Relation to forest fires
Joint declaration of intent by Norway, Germany, UK and Peru (Joint Declaration of Intent/JDI)	Peru the whole nation (land, country)	Norway, Germany United Kingdom	USD 480,000,000 2019-2025	Significantly reduce emissions and support sustainable development in Peru's agriculture, forestry, and mining sectors	Help prevent forest fires by implementing forest loss and hotspot monitoring
Emission Reduction Program (ERP)	San Martin and Ucayali	Forest Investment Program (FIP), Global Environment Facility (GEF), Norway, United States Agency for International Development (USAID), and the Latin American Development Bank (CAF) Forest Carbon Partnership Facility (FCPF	USD 226,155,000 2020-2024	Deterring deforestation in the Amazon Basin with a focus on the states of San Martín and Ucayali	The goal is to reduce logging and greenhouse gas emissions, including forest fire prevention as a cause of forest loss.
Forest fire prevention and response strategies in tropical forests and plantations in Peru. (Forest Fire Prevention and Response in Tropical Forest and Forest Plantations in Peru)	Funin, Pasco, Cajalmaca, Wanukoko, Ucayali	International Tropical木 Timber Organization (ITTO)	USD 1,324,000 2021-2022	Contribute to the conservation of forest ecosystems and strengthen ecosystem protection capacity Promoting forest fire management by strengthening the capacity of national and state governments	The project targets forest fire prevention and management in vulnerable areas of Peru.
Building Wetland Resiliency in	Province of Loreto	Green Climate Fund (GCF)	USD 9,100,000 2017-2022	Strengthening the resilience capacity of	Forest fires are identified as an environmental risk

Project Name/Abbreviation	Target Area	donor	Aid Amount (USD) period of assistance	Purpose and Major Activities	Relation to forest fires
Datum del Marañón County (Building the Resilience of Wetlands in the Province of "Datem del Marañón")	County of Detem del Maraño n			indigenous peoples living in forested areas Reducing Greenhouse Gas Emissions in Wetland Ecosystems in the State of Loreto through Indigenous People's Use of Forests	for the project, including activities to mitigate the risk of forest fires caused and spread by drought.
Prevention and Risk reduction Forest Fires Plan (PPRRIF)	Peru whole country	Japan International Cooperation Agency (JICA) International Tropical木 Timber Organization (ITTO), German International Cooperation力 Public Corporation (GIZ)	USD 511,827 2019-2022	Reduce the occurrence of forest fires to prevent forest and wildlife loss.	Implement capacity building of decision makers, including efforts to reduce the impact of forest fires and forest fire control.
Andean Forest Program (Andean Forests Program)	Andean region[4]	Swiss Agency for Development Cooperation (COSUDE)	USD 1,952,000 2014-2019	Promote integration and expansion of policies, tools, and incentive schemes through forest conservation, carbon storage, water resources, and conservation of native forest species in the Andean region	Facilitate the development of action plans for forest fire prevention and management efforts.
Climate Change Assistance Project	Peru whole country	Swiss Agency for Developme	USD 6426,000 2018-2021	Support for the Peruvian government's greenhouse	Forest management in the Ucayali Region is

[4] Venezuela, Colombia, Ecuador, Peru, Bolivia, Chile, Argentina

Project Name/Abbreviation	Target Area	donor	Aid Amount (USD) period of assistance	Purpose and Major Activities	Relation to forest fires
(Support to the Climate Change Management)		nt Cooperation (COSUDE)		gas reduction and control targets	programmed as a pilot project. Activities related to the reduction of greenhouse gas emissions focus on forest fire control.

Source: Nippon Koei Co.

1.6.2. Brazil

Table 4 summarizes the main aid projects in the past decade related to forest fires in the Brazilian legal Amazon, including donors, aid amounts, aid agencies, and main activities.

Table 4 Regional Cooperation Projects Related to Forest Fires (Brazil)

Project name	donor	Aid Amount (USD) period of assistance	Purpose of Activity and Activities Related to Forest Fires
Amazon Forest Fund[5]	Earth Alliance	USD 5 million 2019	Provides financial support to local NGOs and indigenous communities implementing activities related to forest conservation in the Amazon. NGO: Forest Protection Association (Assistance to the Kayapo Tribe)[6] Indigenous Organization: Confederation of Brazilian Amazonian Indio Organizations (COIAB)[7] NGO: KABU Institute (support for the Kayapo people)[8] NGO: Raoni Institute (assistance to the Kayapo people)[9] NGO: Institute for Social and Environmental Studies (ISA)[10]
Chronic fire emergencies (Fogo Emergência crônica)[11]	Italy	USD 3 million 1999-2002	The Life Center Institute (ICV) took the initiative to improve the chronic emergency situation of forest fires during droughts in 11 Amazonian municipalities by reaching out to relevant stakeholders (City Council for the Environment (COMDEMA), City Hall, Ministry of Agriculture, Fire Department, Brazilian Institute of Environment and Renewable Natural Resources (IBAMA),

[5] https://ealliance.org/amazonforestfund/ (accessed on 2022.2.20)

[6] https://florestaprotegida.org.br/ (accessed on 2022.2.20)

[7] https://coiab.org.br/ (accessed on 2022.2.20)

[8] https://www.kabu.org.br/ (accessed on 2022.2.20)

[9] https://institutoraoni.org.br/ (accessed on 2022.2.20)

[10] https://www.socioambiental.org/pt-br (accessed on 2022.2.20)

[11] https://antigo.mma.gov.br/estruturas/225/_arquivos/4___amaznia___encontrando_solues_225.pdf (accessed on 2022.2.20)

Project name	donor	Aid Amount (USD) period of assistance	Purpose of Activity and Activities Related to Forest Fires
			and labor unions) to raise awareness and encourage and facilitate the transition from slash-and-burn to agro-tourism.
Support for National Forest Fire Prevention and Control Center	Amazon Foundation (Norway, Germany)[12]	USD 2.64 million 2014-2020	Support the IBAMA National Forest Fire Prevention and Control Center (PREVFOGO) in the development of infrastructure and strengthening of its operational structure to raise awareness and provide environmental education to local stakeholders on the monitoring, prevention and control of forest fires and unauthorized burning in the Amazon biome.[13]
Forest Conservation Project in Tocantins (Proteção Florestal Tocantins)		USD 1.2 million 2012-2019	Monitoring, prevention, and assistance in combating deforestation caused by forest fires and unauthorized use of fire in Tocantins through training for environmental protection officers stationed in Alaguia, strengthening of integrated management mechanisms, and assistance in procurement of equipment.
Project to support the Mato Grosso State Forest Fire Brigade (Bombeiros Florestais de Mato Grosso)		USD 2.25 million 2011-2017	Provision of aircraft, vehicles, and support equipment for the air and ground operations base of the Mato Grosso military fire brigade stationed in Sorriso; monitoring, prevention, and assistance in combating forest destruction caused by forest fires and unauthorized fire use in Mato Grosso.
Zero Forest Fires Project in Akure State (Acre: Incêndios Florestais Zero)		USD 2,38 million 2012-2016	Monitored, prevented, and assisted in combating deforestation caused by forest fires and unauthorized slash-and-burn in Akure State.
Pará Combatendo os Incêndios Florestais e Queimadas Não Autorizadas (Project for the Prevention of Forest Fires and Illegal Burning in the State of Pará)		USD 3 million 2012-2020	Support for activities to monitor, prevent, and eliminate deforestation caused by forest fires and unauthorized burning by fire brigade management agencies established in 14 municipalities in the state of Pará.
Hondonia Green Project (Rondônia mais Verde)		USD 2.70 million 2012-2021	Assistance in monitoring, preventing, and taking action to combat deforestation caused by forest fires and unauthorized burning in the province of Hondonia through training in the use of firefighting equipment.
Amazon Forest Fire Fighting	Japan, United	USD 818,000	Provision of fireproof clothing, fireproof gloves, helmet sets, water purifiers, etc., a

[12] Available at: http://www.fundoamazonia.gov.br/pt/carteira-de-projetos/busca/index.html?facet_category_exact=tema/combate -a-incendios-queimadas/&reloaded&page=2 (accessed on 2022.2.20

[13] http://www.fundoamazonia.gov.br/pt/projeto/Prevfogo---Ibama/ (accessed on 2022.2.20)

Project name	donor	Aid Amount (USD) period of assistance	Purpose of Activity and Activities Related to Forest Fires
Support Project[14]	Nations Office for Project Services (UNOPS)	Year 2020	successor activity to the provision of emergency relief supplies for approximately 1,000 people, including tents and sleeping bags, which was carried out through JICA in September 2019.
Emergency Amazon Fire Fund for Brazil and Bolivia[15]	World Wide Fund for Nature (WWF)	USD 1.39 million 2019-2021	World Wide Fund for Nature (WWF) funding for the following uses in response to forest fires in Bolivia and Brazil - Firefighting equipment such as gloves, safety glasses, dampers, coastal pumps, machetes, chainsaws, water pumps and hoses - Providing food, water, and medical supplies to affected communities - Communication radio, GPS - Rental cars and fuel to deliver supplies to remote areas - Equipment and training for fire risk management
REM MATTGROSSO Program (REM MT)[16]	German Development Bank (KfW), British Government	USD 45,110 Year 2021	Financing of sub-programs of family agriculture in the Amazon, Cerrado and Pantanal, indigenous communities, sustainable production in indigenous territories, innovation, application and development of institutional strengthening and public policy building in state agencies, etc., with the aim of promoting sustainable development and implementing the REDD+ mechanism The program is designed to.
Mapfire Project (MapFire)[17]	Inter-American Institute on Global Change (IAI)	-	(1) Quantify the impact of fires in the Amazon basin and develop methods for estimating current and future fire probabilities. (2) Develop fire occurrence diagnostics, operationalize fire monitoring and prevention protocols for wildfire risk management, and identify challenges and bottlenecks in community-based strategies. (3) Support population risk awareness and capacity/resilience building. (4) Provide technical reporting to the Amazon region by standardizing terminology among actors and identifying information flows for policy changes, and assist in the development of basin-wide conservation strategies and policies.
Amazon Project without Fire	Latin American Development	2000-2010 (Brazil)	As part of the sustainable land use policy promoted by the government, training, extension, and development of alternatives to

[14] https://www.gov.br/abc/pt-br/assuntos/noticias/brasil-japao-e-unops- cooperam-para-combater-incendios-florestais-na-regiao -amazonica (accessed on 2022.2.20)

[15] https://files.worldwildlife.org/wwfcmsprod/files/Publication/file/3ao3p1z7t6_Amazon_May_Update.pdf?_ga=2.66923886.1982601132.1635451359-1690308615.1635451359 (accessed 2022.2.20)

[16] https://www.giz.de/en/worldwide/73732.html (accessed on 2022.2.20)

[17] http://www.treeslab.org/map-fire.html (accessed on 2022.2.20)

Project name	donor	Aid Amount (USD) period of assistance	Purpose of Activity and Activities Related to Forest Fires
(Amazon without Fire)	Bank (CAF), Brazilian Cooperation Agency (ABC), Italian Agency for Development Cooperation (AICS)	2011-2017 (Bolivia) 2012-2022 (Ecuador)	slash-and-burn livelihoods are provided to reduce forest fires and improve living conditions in rural areas.

Source: Nippon Koei, *USD = R$5.57/USD

1.6.3. Bolivia

The main aid projects related to forest fires in Bolivia over the past 10 years are summarized in Table 5, including donors, aid amounts, implementing agencies, aid duration, and main activities.

Table 5 Regional Cooperation Projects Related to Forest Fires (Bolivia)

donor	implementing agency	Aid amount (USD/ EUR) period of assistance	Purpose of Activity and Activities Related to Forest Fires
United Nations Development Programme (UNDP)/Global Environment Facility (GEF) Small Grants Program	Friends of Nature Foundation (FAN), Ocquis, San Martín, Tuca Baca Reserve, Puerto Suárez and Puerto Quijaro Municipalities, Chiquitano-Hermann Bush Indigenous District	USD 39,646.8 October 2020-February 2021	Strengthening fire risk management capacity for communities around the three protected areas. Participatory reflection and awareness-raising, training, and equipment provision based on the successful case of forest fire recovery in the Chiquitania region and awareness-raising and adaptation in the Pantanal region.
Auxilium (Switzerland)	-	USD 172,652 September 2011-December 2014	Community fire management around the Chiquitano area. The objectives of the project are to reduce the impacts of forest fires on climate change, biodiversity, and society; promote community forest management in the northern Amazon region of Bolivia; develop and implement early warning systems; and monitor and prevent fires and fire prevention in the region.
Government of Canada	Chiquitano Forest Conservation Fund Noel Kemp Mercado Museum	March 2021	Comparative assessment of the characteristics of vegetation lost to forest fire and remaining vegetation in four pilot districts.
Government of Canada	non-governmental organization (Naturaleza, Tierra y Vida, NATIVA)	USD 38,000 2021-2022	Establishment of a forest fire early warning, prevention, and monitoring system to improve the resilience of landscape conservation areas to forest fires in Bolivia

donor	implementing agency	Aid amount (USD/ EUR) period of assistance	Purpose of Activity and Activities Related to Forest Fires
			(Cahuilla Conservation Area) and Paraguay (Defensores Conservation Area).
Food and Agriculture Organization of the United Nations (FAO)	-	USD 500,000	Forest fire prevention measures in the Chiquitano area.
Latin American Development Bank (CAF), Brazilian Cooperation Agency (ABC), Italian Agency for Development Cooperation (AICS)	The Amazon Without Fire Program (PASF)	EUR 4.83 million 2000-2010 (Brazil) 2011-2017 (Bolivia) 2012-2022 (Ecuador)	Introducing alternative energy sources for fire suppression in the Bolivian Amazon region, protecting the environment, improving the livelihoods of indigenous communities, and strengthening the capacity of local governments to plan and implement forest fire control measures.
Food and Agriculture Organization of the United Nations (FAO)	-	USD 434,169 June 2020 - May 2021	Risk Management and Resilience Project in the Chiquitania Region. Identification of drought and forest fire threats affecting agriculture-based livelihoods. Strengthening of near-term response, rehabilitation, improved comprehensive risk management, and resilience of the most vulnerable indigenous communities whose livelihoods depend on agriculture and forests.
United Nations Children's Fund (UNICEF) HELVETAS (Switzerland, NGO)	World Vision	USD 22,966 2021	Livelihood restoration support for indigenous communities in the Chiquitania region
Eikenstein Geigy Foundation (Switzerland)	-	USD 41,557 2020-2023	A sustainable landscape project in the Bolivian Amazon. Climate change and disaster resilience strengthening (including activities on gender, social equity, capacity building, partnership strengthening, and nutrition).

Source: Nippon Koei Co.

1.6.4. Colombia

The main aid projects related to forest fires in Colombia over the past decade are summarized in Table 6, including donors, aid amounts, implementation periods, and main activities.

Table 6 Regional Cooperation Projects Related to Forest Fires (Colombia)

Project name	donor	Aid Amount (USD) implementation period	Purpose and Main Activities	Forest fire related
Forest Conservation and Sustainability in the Heart of the Colombian Amazon[18]	World Bank (WB), Global Environment Facility (GEF)	USD 122.8 million 2015-2024	Improve governance, promote sustainable land use activities, and work to reduce deforestation and conserve forests.	Direct measures against forest fires are not included.
Conservation and sustainable use of biodiversity in arid ecosystems to ensure the flow of ecosystem services and mitigate deforestation and desertification processes[19]	United Nations Development Programme (UNDP), Global Environment Facility (GEF)	USD 32.9 million 2014-2020	Promote sustainable forest management, regeneration, afforestation, and conservation.	Direct measures against forest fires are not included.
Biodiversity Conservation in the Landscape of the Choco Biogeographic Region Affected by Mining Development[20]	United Nations Development Programme (UNDP), Global Environment Facility (GEF), World Wide Fund for Nature (WWF)	USD 30.6 million 2014-2018	Improve national, provincial, and local management capacity for integrated land management and promote sustainable environmental management and risk management.	Direct measures against forest fires are not included.
Strengthen institutions and policies for biodiversity	United Nations Development Programme	USD 2.2 million 2011-2014	Improve the legal and policy framework and strengthen institutions through pilot activities in the Llanos region	Although it does not include direct measures against forest fires, it does position fire as a threat

[18] https://projects.worldbank.org/en/projects-operations/project-detail/P144271 (accessed on 23.11.2022)

[19] https://www.undpopenplanet.org/projects/Conservation_and_sustainable_use_of_biodiversity_in_dry_ecosystems_to_guarantee_the_flow_of_ecosystem_services_and_to_mitigate_the_processes_of_deforestation_and_desertification/ (accessed on 2022.11.23)

[20] https://www.thegef.org/projects-operations/projects/4916 (accessed on 23.11.2022)

Project name	donor	Aid Amount (USD) implementation period	Purpose and Main Activities	Forest fire related
conservation in Production Lands[21]	(UNDP), Global Environment Facility (GEF)		(Llanos), thereby promoting voluntary biodiversity conservation activities in pastoral and forestry production areas.	to ecosystem conservation, but it does mention the use of fire in production areas.
Using Traditional Knowledge Related to Biodiversity in Colombian Agroecosystems.[22]	United Nations Development Programme (UNDP), Global Environment Facility (GEF)	USD 7 million 2011-2012,. 2013-2014	Conserve sustainable agroecosystems by protecting and managing agrobiodiversity and associated traditional knowledge.	Direct measures against forest fires are not included.
Mainstreaming biodiversity and ecosystem approaches in oil palm harvesting in Colombia[23]	Inter-American Development Bank (IDB), Global Environment Facility (GEF)	USD 14 million 2012-2016	Contribute to mainstreaming biodiversity conservation in oil palm systems by strengthening the planning and adoption of agroecological practices in areas where expansion of oil palm cultivation is a priority	Direct measures against forest fires are not included.
Paramo Conservation Project (Páramos para la Vida)[24]	Global Environment Facility (GEF), Government of Colombia	USD 74 million	Strengthening the capacity of the Palamo Ecosystem[25] management and participatory monitoring of biodiversity and related ecosystem services.	Direct measures against forest fires are not included.
International Firefighting Cooperation	Japan International	-	Establish policies, activities, responsibilities, , and	Strengthening of the capacity and equipment of

[21] https://www.thegef.org/projects-operations/projects/4111 (accessed on 23.11.2022)

[22] https://www.thegef.org/projects-operations/projects/3604 (accessed on 23.11.2022)

[23] https://www.thegef.org/projects-operations/projects/4113 (accessed on 23.11.2022)

[24] https://www.undp.org/es/colombia/projects/paramos-para-la-vida(accessed November 23, 2022)

[25] A páramo ecosystem is an ecosystem in an area above the contiguous forest limit and below the snow line and refers to a tropical alpine ecosystem with vegetation consisting primarily of rosette plants, shrubs and grasses (Baruch, Zdravko (20 March 1984). "Ordination and Classification of Vegetation along an Altitudinal Gradient in the Venezuelan Páramos". Vegetation. 2. 55 (2): 115-126.)

Project name	donor	Aid Amount (USD) implementation period	Purpose and Main Activities	Forest fire related
Alliance Project [26]	Cooperation Agency - Disaster Risk Management Unit (JICA-UNGRD), Fire Fund, Chilean Agency for International Cooperation (AGCI), Spanish Agency for International Development (AECID), Organization for the Prohibition of Chemical Weapons (OPCW)		guidelines for fire agencies, Colombian National Fire Service (DNBC) personnel, and contractors to ensure optimal management of resource procurement through donors, strategic partners, and the private sector.	firefighters responding to forest fires will be implemented.

Source: Nippon Koei Co.

1.6.5. Response measures for major forest fire drivers

The drivers of forest fires as sub-problems (causes) are extremely wide-ranging and diverse. Furthermore, given the complex factors that cause forest fires and their complex structure, it is neither efficient nor effective to analyze individual drivers and to develop a support frame from a multidimensional perspective.

Despite the diversity of forest fire driver measures, the relevant government agencies in each country responsible for prevention and response to forest fires are assigned tasks by stage (prevention, detection, fire suppression, site restoration, etc.), cause of fire, land where the fire occurred, and activity, and work together to fulfill their respective roles in forest fire The team was found to be responding to the forest fires in a cooperative manner to fulfill their respective roles. Identifying those tasks and assigning and categorizing them into appropriate frames would be useful for considering feasible and understandable support frames.

In 2019, FAO developed a Forest Fire Management Strategy that sets out an approach to fire management that will assist member countries.[27] FAO has identified three goals for the Forest Fire Management Strategy: 1) promote understanding of Integrated Fire Management (IFM), 2) identify or develop high quality data collection and analysis, systems and processes, 3) Identify information delivery mechanisms and provide technical assistance to rural areas or communities.

[26] https://dnbc.gov.co/sites/default/files/2019-12/informe_de_gestion_cooperacion_internacional_i_sem_2017.pdf (accessed on 2022. November 23)

[27] FAO 2019, "Strategy on Forest Fire Management" (https://www.fao.org/3/cb6816en/cb6816en.pdf)

Integrated Fire Management (IFM) is positioned as a key concept in FAO's forest fire management and attempts to integrate fire management by setting an overall frame and then seeking long-term, sustainable solutions using five cause-focused components (referred to as the 5Rs), as follows The project is attempting to integrate forest fire management by using the 5Rs to define the overall frame and then seeking long-term sustainable solutions.

Table 7: Five Elements of Integrated Fire Management (IFM) (5Rs

Elements	Main Objective
Review	Analysis of fire problems and identification of options for remediation.
Risk Reduction	Prevention of forest fires and addressing the root causes of fires.
Readiness	Preparedness to fight forest fires, including monitoring related to forest fires, management of fuels (deposited biomass), and monitoring of human activities.
Response	Achieving an appropriate response to damaging forest fires.
Recovery	community welfare, infrastructure restoration, and restoration of landscapes damaged by wildfires.

Source: Compiled by Nippon Koei Co. based on FAO 2019

1.7. Possibility of future support by Japan

In this section, we summarize the potential for support by country, based on the support needs of the key actors identified in this study. In addition, the following points were taken into consideration in the identification of needs.

(1) Consistent with the policy, institutional, and strategic direction of the target countries.
(2) Based on the implementation capacity of government agencies in the target countries.
(3) Various schemes of Japanese bilateral assistance (technical cooperation, SATREPS, grant aid, yen loans, dispatch of individual experts and cooperative members, etc.) should be available.
(4) The project must be consistent with Japan's and JICA's aid policies for the target countries.

JICA's assistance to the target countries should be based on JICA's past experience in providing assistance.

1.7.1. Peru

The following are the main ideas for possible cooperation in Peru, divided into the national and regional levels.

middle level

Table 8: Ideas for main possible cooperation details (Peru, central level)

Anticipated Project Name	Anticipated Project Objectives	Anticipated Scheme	Project Classification	Examples of Implementing Agencies of Partner Governments (Underlines are central institutions)	Project Target Areas
Improvement of data transfer of hotspots information to regional and local governments	To improve and speed up the transfer of information on hotspots to the regional and local governments level.	Technical cooperation	Readiness	SNCVFFS/MIDAGRI, SINIA, CGBVP, regional and local governments	Peru as a whole

Anticipated Project Name	Anticipated Project Objectives	Anticipated Scheme	Project Classification	Examples of Implementing Agencies of Partner Governments (Underlines are central institutions)	Project Target Areas
of the Peruvian jungle					
Program of identification and replacement of crops that require the use of fires	To identify crops which require the use of fire for their proper cultivation and propose alternatives for them.	SATREPS	Review	INIA/MIDAGRI, National Agrarian University - La Molina (UNALM) (and other universities), regional and local governments	Peru as a whole
Elaboration of a manual for rural governments for the prevention and control of forest fires	To promote appropriate non-fire methodologies for agricultural producers in forest land	Technical cooperation	Review	CGBVP, SERFOR/MIDAGRI, CENEPRED, COER, INDECI, UNALM	Peru (focusing on the areas with soils classified as for forestry use with records of agricultural activities)
Enhancement of a network for the early detection of forest fires that involves local governments	To enhance a network of entities for the early detection of forest fires that involves regional and local governments	Technical cooperation	Readiness	SERFOR/MIDAGRI, SERNANP (MINAM), regional and local governments, COER, CGBVP, CEPLAN, INDECI, CGBVP	Peru as a whole

Source: Nippon Koei Co.

local level

Table 9: Main Ideas for Possible Cooperation (Peru, regional level)

Anticipated Project Name	Anticipated Project Objectives	Anticipated Scheme	Project Classification	Examples of Implementing Agencies of Partner Governments (Underlines are central institutions)	Project Target Areas
Capacity development for the prevention and management of forest fires of regional government in Ucayali	To strengthen the capacity of regional government of Ucayali and CGBVP-Ucayali for forest fire response	Technical cooperation/ Grant aid	Readiness Response	GORE Ucayali, CGBVP-Ucayali, SERFOR/MIDAGRI, SERNANP/MINAM	Ucayali region with emphasis on rural areas
Optimize "slash-and-burn" technology in Ucayali's	The use of "slash-and-burn" technology is optimized in the	Technical cooperation/ SATREPS	Review Readiness	GORE Ucayali (Regional Directorate of Agriculture), National Agrarian	Ucayali region

Anticipated Project Name	Anticipated Project Objectives	Anticipated Scheme	Project Classification	Examples of Implementing Agencies of Partner Governments (Underlines are central institutions)	Project Target Areas
tropical forest ecosystem	tropical forest areas of Ucayali			University - La Molina (UNALM) (and other universities), INIA (MIDAGRI), CGBVP NGOs	
Reinforcement and development of agroforestry techniques in Ucayali	To increase the use of agroforestry techniques to diminish the use of the slash-and-burn technique and prevent forest fires	Technical cooperation	Readiness	GORE Ucayali (Regional Directorate of Agriculture), INIA/MIDAGRI, SERFOR/MIDAGRI, UNALM	Ucayali region
Capacity development of communities for initial reaction and community warning on forest fire in Ucayali	To instruct the rural population of Ucayali how to react and proceed in the presence or possibility of forest fire	Technical cooperation	Response	GORE Ucayali (Regional Directorate of Agriculture), CGBVP-Ucayali, CGBVP, SERNANP (MINAM), SERFOR (MIDAGRI)	Ucayali region

Source: Nippon Koei Co.

1.7.2. Brazil

The following are the main ideas for possible cooperation in Brazil, divided into the national and local levels.

national level

Table 10: Main cooperation ideas to be defined (Brazil, national level)

Anticipated Project Name	Anticipated Project Objectives	Anticipated Scheme	Project Classification	Examples of Implementing Agencies of Partner Governments (Underlines are central institutions)	Project Target Areas
Advance in the implementation and proper utilization of the National Fire Information System (SISFOGO)	To advance in the implementation and proper utilization of the National Fire Information System (SISFOGO)	Technical cooperation	Readiness	PREVFOGO / IBAMA	Brazil as a whole
Improving the forest fire management in Conservation	To strengthen the monitoring, the prevention, and the response to	Technical cooperation	Readiness Response	ICMBIO	Brazil (Selected Protected Areas in

Units located in the transition of Amazon and Cerrado biomes	forest fires capabilities in the federal and state conservation units				transition of Amazon and Cerrado biomes)
Prevention of fires through better understanding of future climate conditions	To improve the efficiency of forecasting severe droughts and forest fires	Technical cooperation	Review	CEMADEN.	Brazil as a whole

Source: Nippon Koei Co.

local level

Table 11: Main Ideas for Possible Cooperation (Brazil, Local Level)

Anticipated Project Name	Anticipated Project Objectives	Anticipated Scheme	Project Classification	Examples of Implementing Agencies of Partner Governments (Bolded type is the central institution)	Project Target Areas
Capacity development for forest fire prevention and response in the Amazon and Cerrado Biome Transition Zones	Through the introduction of Integrated Fire Management (IFM), to enhance the capacity of state-level fire departments	Technical cooperation/Grant aid	Readiness Response	PREVFOGO/IBAMA BEA/CBMMT, SEMA	States of Acre, Rondonia, Mato Grosso, Para and
Capacity development for the prevention and combatting of forest fires of Mato Grosso	To improve the capabilities of the state level firefighting related organizations	Technical cooperation/Grant aid	Response	BEA/CBMMT, SEMA	Mato Grosso State (or Tocantins or Maranhão)
Capacity development of vulnerable communities about forest fire impacts in Mato Grosso	To increase the capabilities of vulnerable communities to prevent, combat and recover from forest fires	Technical cooperation/Grant aid	Readiness Response Recovery	SEMA, ICV, IPAM	Mato Grosso State (or Tocantins or Maranhão)

Source: Nippon Koei Co.

1.7.3. Bolivia

The following are the main ideas of cooperation content envisioned in Bolivia, divided into the national and local levels.

national level

Table 12: Ideas for main possible cooperation details (Bolivia, national level)

Anticipated Project Name	Anticipated Project Objectives	Anticipated Scheme	Project Classification	Examples of Implementing Agencies of Partner Governments (Bolded type is the central institution)	Project Target Areas
Strengthening of capacities on Integrated Fire Management (IFM) and prevention of forest fires	To reduce the risk of forest fires by strengthening capacities for Integrated Fire Management (IFM) and Fire Fighters	Technical cooperation	Readiness	ABT (former Soviet Union intelligency agency)	Bolivia as a whole
Risk reduction through the prevention and control of forest fires	To strengthen the capacities of local actors for planning, application of practices focused on the correct use of fire, early warning, and reflection and To strengthen capacities of local actors for planning, application of practices focused on the correct use of fire, early warning, and reflection and awareness on the problem of forest fires	Technical cooperation	Readiness	DGGDF/MMAyA	Bolivia as a whole
Climate Smart Territories (CMT) for efficient and sustainable management to face climate change and forest fires	To develop alternatives to the use of fire through defining methodologies of CMT	SATREPS	Review Risk Reduction	Gabriel Rene Moreno University and other universities with expertise	Bolivia as a whole

Source: Nippon Koei Co.

local level

Table 13: Ideas for main possible cooperation details (Bolivia, local level)

Anticipated Project Name	Anticipated Project Objectives	Anticipated Scheme	Project Classification	Examples of Implementing Agencies of Partner Governments (Bolded type is the central institution)	Project Target Areas
Dissemination and enlightenment for management methods of slash-and-burn technology that	To control and improve the use of "chaqueos" technique to reduce the risk of forest fire spread	Technical cooperation	Readiness Response	GAD - Santa Cruz, ABT	Department of Santa Cruz

Anticipated Project Name	Anticipated Project Objectives	Anticipated Scheme	Project Classification	Examples of Implementing Agencies of Partner Governments (Bolded type is the central institution)	Project Target Areas
leads to forest fires					
Restoration and conservation of ecosystem functions and biodiversity of affected areas by forest fires	To counteract the negative effects that have deteriorated the ecosystems and the quality of life in the affected aeras, through restoration, rehabilitation, and recovery activities rehabilitation, and recovery activities	Technical cooperation	Recovery	GAD - Santa Cruz, California MMAyA, Affected municipal governments (GAM) by forest fire	Department of Santa Cruz
Control and management of permits for the use of agricultural burning	To strengthen fire use monitoring and management capacity of fire on agricultural lands	Technical cooperation	Risk Reduction	GAD - Santa Cruz, ABT	Department of Santa Cruz

Source: Nippon Koei Co.

1.7.4. Project Profile

Two business profiles from the short list are proposed below.

1.7.4.1. Peru

Profile No. 1: Project for Capacity Building of Ucayali District Administration for Forest Fire Prevention and Management (Peru)

1. Project Name	Capacity Building of Ukayali District Administration for Forest Fire Prevention and Management
2. Project Background	The volunteer fire brigade (CGBVP-Ucayali) is expected to play a significant role at the scene of fires in the Ucayali region. However, while volunteer fire brigades are trained to extinguish building fires, respond to accidents, and provide medical assistance in urban areas, they are not sufficiently trained to deal with forest fires. On the other hand, resources such as equipment and materials needed at the fire scene are extremely limited, and cooperation among various agencies related to forest fires is not always sufficient, leading to inefficient fire prevention and extinguishing measures. Efficient forest fire field operations require coordination between various agencies at the state level, especially with central government agencies such as MIDAGRI and MINAM, but state governments do not have sufficient capacity to do so. Against this background, this project aims to support the improvement of fire fighting efficiency at forest fire sites in rural areas in terms of provision of materials and equipment and technology transfer, as well as to strengthen cooperation with relevant agencies at the central and state levels.
3. Potentially Applicable JICA Schemes	technical cooperation Grant aid (provision of materials and equipment, etc.)
4. Relevant agency of the partner country's government	<Implementing Agency> GORE Ucayali, CGBVP-Ucayali <Cooperating institutions> SERFOR/MIDAGRI, SERNANP/MINAM, COER

5. Project Target Areas	Ukayali region
6. Project Objectives	The capacity of the Ukayali Regional Government and the Ukayali Branch of the Volunteer Fire Brigade to deal with forest fires will be strengthened.
7. Major activity components	(1) Strengthening forest fire alert and initial response capabilities (2) Conducting educational activities related to forest fire prevention and response in rural areas (3) Strengthen coordination and collaboration with related organizations (4) Provision of equipment and materials and necessary training (grant aid)
8. Expected Results	1) Community-level vigilance and initial response capacity to forest fires will be strengthened. 2) Community-level awareness of the need to prevent forest fires will be enlightened. 3) The initial response capabilities of state agencies to forest fires will be strengthened. 4) Coordination between state and central government agencies will be facilitated. 5) It will be strengthened in terms of equipment and technology used (grant assistance).

Source: Nippon Koei Co.

Profile No. 2: Project for Optimization of "Slash and Barrow" Technology in Tropical Forest Ecosystems of the Ucayali Region (Peru)

1. Project name	Project for optimization of "slash and burn" technology in tropical forest ecosystems in the Ucayali region.
2. Project Background and Overview	Although slash-and-burn agriculture is widely and commonly practiced in rural areas of Peru, many cases have been reported where it has led to serious damage because, due to lack of awareness of fire management, it often spreads to areas other than those originally intended and is difficult to control in many cases. Leaving the use of such methods in their current state means leaving a major risk in forest fire control. Therefore, thorough control of burning techniques and fire management is considered an important forest fire control responsibility, especially for local governments. However, there are no technical guidelines for the use of slash-and-burn burning, nor are there sufficient awareness-raising activities aimed at proper use. There are also insufficient measures to improve livelihoods to reduce dependence on slash-and-burn. This project, with the Regional Government of Ucayali, one of the provinces most affected by forest fires in Peru, as a counterpart, will work with central government agencies to improve the capacity of communities to manage slash and burn and to promote the appropriate use of slash and burn technology in their communities.
3. Potentially Applicable JICA Schemes	Technical Cooperation Projects Scientific and Technological Cooperation (SATREPS)
4. Relevant agency of the partner country's government	<Implementing Agency>GORE Ucayali (Regional Directorate of Agriculture), SERFOR (MIDAGRI) <Cooperating Organizations>UNALM, SERNANP (MINAM), CGBVP-Ucayali
5. Project Target Areas	Ukayali region
6. Project Objectives	The optimization of the use of "slash and burn" techniques will be promoted in the tropical forest areas of the Ukayali region.

7. Major activity components	(1) Identification of forest fire prevention measures and development of action plans related to "burning." (2) Development of appropriate technology for the use of "burning fields" (3) Development and diffusion of agriculture and agroforestry technologies that do not rely on "slash and burn" techniques (4) Educational activities on the proper use of "slash and burn" techniques
8. Expected Results	1) Measures are being taken to prevent forest fires from spreading to large scale (underbrush management, installation of firebreaks). 2) A technical manual (precautionary measures, use of burning) will be developed. 3) The following technologies will be developed that do not rely on "slash and burn" techniques o Alternative agricultural technologies that do not involve land change in land use o Agroforestry, Silvopasture, Agrosilvopasture and other forest-based agricultural technologies o Improvement of slash-and-burn farming methods and productivity 4) Agriculture and agroforestry technologies that do not rely on "slash and burn" techniques will be promoted. 5) Community awareness will be raised regarding "responsible use of fire," "responsible agriculture," and the dangers of "slash and burn."

Source: Nippon Koei Co.

1.7.4.2. Brazil

Profile No. 3: Capacity Building Project for Forest Fire Prevention and Control in the Transition Zone of the Amazon and Cerrado Biomes (Brazil)

1. Project name	Capacity building project for forest fire prevention and control in the transition zone of the Amazon and Cerrado biome
2. Project Background and Overview	The "arc of deforestation," located in the southern part of the Amazon Basin, is a particularly fragile ecosystem that is largely comprised of the transition zone between the Amazon and the Cerrado Biome. This region has the highest risk of desertification and the highest risk of biodiversity loss, yet it has the highest number of forest fires, and urgent action is required. Five states (Acre, Rondonia, Mato Grosso, Para, and Tocantins) are located in this transition zone, and strengthening response capacities such as fire prevention and suppression in these states to reduce the number of forest fires and to prevent large fires is one of the most This is one of the highest priority issues in the fight against forest fires in Brazil as a whole. This project aims to strengthen the implementation of integrated fire management in each state, with the central government agency, IBAMA, as the contact agency. In Mato Grosso, the most severely affected state and the one that has received the most support in the past, pilot activities will be conducted on advanced initiatives, with a view to subsequent expansion to other states.
3. Potentially Applicable JICA Schemes	technical cooperation Grant aid (provision of materials and equipment, etc.)

4. Relevant agency of the partner country's government	<implementing agency> (Central Government) (Local Government)BEA (Batalhão de Emergências Ambientais)/CBMMT (Corpo de Bombeiros Militar de Mato Grosso), SEMA <Cooperating Institutions> ICMBIO, FUNAI
5. Project Target Areas	Five states (Acre, Rondonia, Mato Grosso, Para, and Tocantins) in the transition zone to the Amazon and Cerrado biome. However, the pilot activity will cover the state of Mato Grosso.
6. Project Objectives	The capacity of each fire-related organization at the state level will be enhanced through the implementation of Integrated Fire Management (IFM).
7. Major activity components	(1) Promote collaboration with local communities and large farmers on fire management (2) Develop and implement an underbrush fuel management program to prevent the spread of fire (3) Development of small-scale infrastructure for forest fire prevention and control (4) Establish a platform for sharing information among states (5) Conduct awareness and training on community disaster prevention and initial response (6) Promoting Integrated Forest Management (IFM) by State Governments (7) Provision of materials and equipment (grant aid)
8. Expected Results	1) Community awareness-raising and initial response capabilities will be improved. 2) A management program for underbrush fuels to prevent the spread of fire will be developed and implemented. 3) A small infrastructure will be established to prevent the spread of fire. 4) More cases of Integrated Forest Management (IFM) will be applied. 5) Cooperation agreements with large farmers for initial response and monitoring will be signed. 6) Improved monitoring and early warning actions by local communities and large farmers. 7) The number of forest fires exposed and the number of penalties applied will increase. 8) Materials, equipment, personnel and capacity will be enhanced.

Source: Nippon Koei Co.

Profile No. 4: Project to Implement and Promote the Proper Use of the National Fire Information System (SISFOGO) (Brazil)

1. Project name	National Fire Information System (SISFOGO) Implementation and Appropriate Use Promotion Project
2. Project Background and Overview	SISFOGO is the central system for forest fire monitoring and suppression in Brazil. information and analysis collected in central government agencies such as IBAMA and the Federal Police are integrated in SISFOGO and are expected to be useful in the field of forest fires in each state, but currently this PREVFOGO is part of IBAMA, which was established specifically for forest fire preparedness, and is responsible for the operation and improvement of SISFOGO. The project aims to strengthen PREVFOGO's capacity

	for the proper use of SISFOGO and will implement various related activities in cooperation with ICMBIO, which has jurisdiction over the federal protected areas, and FUNAI, which has jurisdiction over the indigenous protected areas.
3. Potentially Applicable JICA Schemes	technical cooperation
4. Relevant agency of the partner country's government	<Implementing Agency>PREVFOGO / IBAMA <Cooperating Institutions > ICMBIO, FUNAI
5. Project Target Areas	Nine legal Amazonian states (covering about 60% of Brazil's land area) <Pilot site> Natural and indigenous reserve located in the Cerrado Baïm in legal Amazonia
6. Project Objectives	National Fire Information System (SISFOGO) effectiveness and proper use will be promoted.
7. Major activity components	(1) Development of centralized monitoring system and operational guidelines (2) Provide training on the operation of the centralized monitoring system (3) Provide SISFOGO with information to relevant agencies and streamline decision-making (4) Promote collaboration among forest fire related organizations
8. Expected Results	1) A system will be established to visually transmit monitored forest fire alerts to local governments and firefighting organizations that directly respond to forest fires, with no time lag. 2) Integration of useful data and information networks and systems for forest fire management into SIFOGO will be facilitated. 3) Networking and communication efficiency between federal and state actors on forest fire prevention and management will be facilitated. 4) Public-private partnerships will be promoted for forest fire prevention and control.

Source: Nippon Koei Co.

1.7.4.3. Bolivia

Profile No. 5: Project for Restoration and Conservation of Ecosystem Function and Biodiversity in Forest Fire Affected Areas (Bolivia)

1. Project Name	Project for restoration and conservation of ecosystem functions and biodiversity in areas affected by forest fires
2. Project Background and Overview	Forest landscape restoration is known to help restore the ecological functions of forests and improve the livelihoods of the local population through the services provided. In Bolivia, more than 50,000 km$^{(2) \text{ were}}$ affected by fire in 2019, of which approximately 35,000 km^2 (65.75% of the total burned in the country) were affected in the state of Santa Cruz, of which approximately 17,000 km^2 were forest. Against this backdrop, the State of Santa Cruz has developed the "Recovery Plan for Fire Affected Areas in Santa Cruz" for the year 2020. This project aims to support the roles of the Ministry of Environment and Water, the Government of the State of Santa Cruz (GAD), and the local governments (GAM), and to facilitate their collaboration in a manner consistent with this Plan, focusing on recovery after forest fires. The Plan consists of five pillars: Environmental, Social, Production, Tourism/Culture, and Cross-Sectoral/Risk Governance. This project will place particular

	emphasis on the implementation of environmental actions and the promotion of partnerships with other agencies.
3. Potentially Applicable JICA Schemes	technical cooperation
4. Relevant agency of the partner country's government	<implementing agency> (Central Government) MMAyA (Local Government)GAD - Santa Cruz, Municipal Governments affected by forest fires (GAM) <cooperating organization> Ministry of Defence
5. Project Target Areas	Santa Cruz State (26 municipalities affected by forest fires)
6. Project Objectives	Negative impacts of forest fires on the quality of life in the affected areas will be mitigated through restoration, rehabilitation, and rehabilitation activities.
7. Major activity components	(1) Assist in natural renewal and restoration work in fire-affected forests and protected areas (2) Promote activities for biodiversity conservation in forests and protected areas affected by forest fires, as well as in corridor areas connecting them. (3) Promote comprehensive watershed management based on a watershed approach in forests and protected areas affected by forest fires
8. Expected Results	1) Native seed collection and nursery production, as well as training for the same, will be conducted. (MMAyA) 2) Manuals and training will be developed for natural renewal assistance and recovery operations. (MMAyA) 3) An action plan for natural renewal assistance and restoration work in fire-affected forests and protected areas will be developed. (GAD) 4) Affected communities are identified and forestry and agroforestry nurseries are created. (GAD) 5) A study of the effects of forest fires on biodiversity and ecosystem function will be conducted. (MMAyA) 6) A plan will be developed to restore ecosystem functions and biodiversity affected by forest fires. (MMAyA) 7) Priority areas for conservation, priority flora and fauna are identified and their conservation activities are promoted. (MMAyA) 8) An integrated watershed management plan will be developed. (MMAyA, GAD) 9) Monitoring of natural vegetation restoration will be conducted (environmental functions, carbon fixation and release, water balance, surface and groundwater sources, biodiversity corridor functions, etc.) 10) Cooperation agreements with related agencies as well as joint activity agreements are signed. (MMAyA, GAD)

Source: Nippon Koei Co.

Profile No. 6: Dissemination and Awareness Project on Management Practices of Slash and Barrow Techniques Leading to Forest Fires (Bolivia)

1. Project name	Project to disseminate and raise awareness of management practices for slash-and-burn techniques that lead to forest fires
2. Project Background and Overview	Slash-and-burn agriculture, widely known in Bolivia as "chakeo," is a technique commonly used by Bolivian farmers to prepare land for use as agricultural land. This "chakeo" is considered a major cause of forest fires in rural areas. With the increasing frequency of droughts in recent years due to climate change and the growing threat of forest fires having a fatal negative impact on forest ecosystems, the proper management of "chakeos" is recognized as an urgent matter that needs urgent attention. Santa Cruz borders Brazil and is located in the transition zone between the Amazon Biome and the Cerrado Biome, making it the state with the highest risk of forest fires, as 71.3% of all forest fires in Bolivia between 2000 and 2013 occurred in this state. Of the 26 municipalities affected by forest fires, San Matías, San Ignacio de Velasco, Charagua, Concepción, and Puerto Suárez were the top five. This project, in collaboration with the Santa Cruz State Government and the most affected municipal governments, aims to reduce the frequency of forest fires through proper management of "chaqueo" use and to reduce the negative impacts on forest ecosystems by encouraging post-fire vegetation recovery.
3. Potentially Applicable JICA Schemes	technical cooperation
4. Relevant agency of the partner country's government	(Central Government) MMAyA (Local Government)GAD - Santa Cruz Each Pilot Municipal Government (GAM) (San Matías, San Ignacio de Velasco, Charagua, Concepción, Puerto Suárez)
5. Project Target Areas	Santa Cruz State Pilot municipalities (San Matías, San Ignacio de Velasco, Charagua, Concepción, Puerto Suárez)
6. Project Objectives	Improved management and use of "chakeo" technology to reduce the risk of forest fires spreading.
7. Major activity components	(1) Conducting educational activities on the dangers of using "chakeo" technology (2) Conduct community disaster awareness and training for initial response, fire spread prevention and monitoring (3) Formation of a liaison council consisting of representatives of relevant agencies for initial response, fire spread prevention and monitoring (4) Planning of activities and development of small-scale infrastructure for initial response, fire spread prevention and monitoring (5) Development of alternative agricultural technologies and preparation of manuals for their introduction (6) Provide training on alternative farming techniques using manuals
8. Expected Results	1) Community awareness-raising and initial response capacity will be improved. 2) Improved monitoring and early warning actions by local communities. 3) A liaison council will be formed for initial response and monitoring. 4) A small infrastructure will be established to prevent the spread of fire.

	5) The community's reliance on "chakeo" will be reduced. 6) Alternative agricultural techniques for "chakeo" will be promoted.

Source: Nippon Koei Co.

Part 2: Stud of Fires Causes in Southern Africa

2. Investigating the Causes of Fires in Southern Africa

As mentioned in the study area above, the results of this study are expected to directly contribute to the improvement of forest fire management in KAZA-TFCA. Therefore, with the KAZA-TFCA as the scope of analysis, we investigated (1) the current status of forest fire area and frequency, (2) the causes of fire through literature review and other means, and (3) the future impact of fire on the area.

2.1. Fire Outbreak Analysis Methodology

2.1.1. Fire area determination method using satellites (MODIS, LANDSAT)

The MODIS satellite launched by the National Aeronautics and Space Administration (NASA) is used worldwide to detect forest fires. In this study, in addition to the extraction of the fire area by this satellite imagery, analysis of fire site area was conducted using the Landsat satellite imageries. The figure below shows a comparison of the area (ha) of the fire area detected by MODIS and Landsat at five time points (2001-2005-2010-2015-2019) using KAZA-TFCA as the target area.

The results show that the area of the fire area detected by MODIS (blue) is much larger than the area detected by Landsat (red). It is necessary to verify whether either of the detected areas shows more reliable values in the future.

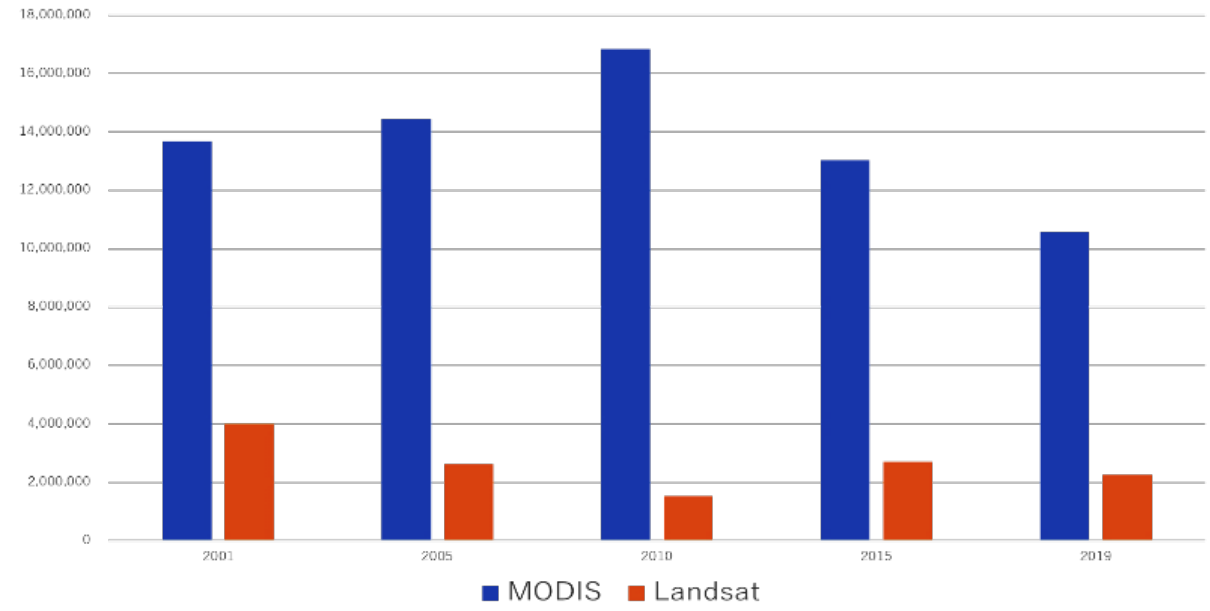


Figure 1: Comparison of fire-initiated site area by MODIS and Landsat

2.1.2. Accuracy verification of fire area detected by MODIS satellite

In the above, we compared the detected area of fire occurrence detected by MODIS and Landsat TM and Landsat7 and found that there is a difference of more than 10 times in the area of fire occurrence detected by both satellites. Since there was a large difference in the detected area in the same region and in the same year, the detection accuracy of the two satellites was verified.

The following two methods of verification were taken.

1) Document review
2) Visual interpretation using Landsat 8 satellite imagery

2.1.2.1. Accuracy verification of fire area detection by MODIS satellite (literature review)

The accuracy of the MODIS fire scar detection function was investigated from existing literature.

☑ literature

Boschetti, et al. (2019). Global validation of the collection 6 MODIS burned area product. Remote Sensing of the Environment 235, 111490

Methodology
In the literature, the fire scars detected by Landsat8 are considered true values, and the accuracy of the fire scars detected by MODIS is compared.

☑ result

MODIS detected a global average of 40.2% excess fire sites (CE: Commission Error) and 72.6% of actual fire sites (OE: Omission Error) (see table below). In Tropical Savanna, a site covered by the GCF-SAP, 60.7% had OE and 35.2% had CE.

Table 14: MODIS fire detection accuracy by forest type as presented in the literature.

Estimated global and per-biome accuracy metrics and total burned area, and associated standard errors derived from the Table 4 estimated confusion matrices. See Equations [5–8] for the accuracy metric definitions and equation [10] for the associated standard errors. See equations [11–12] for the total burned area estimation, and equations [13–14] for the associated coefficient of variation.

Biome	$\hat{OA}$ [%]	$\hat{SE}(\hat{OA})$ [%]	$\hat{OE}$ [%]	$\hat{SE}(\hat{OE})$ [%]	$\hat{CE}$ [%]	$\hat{SE}(\hat{CE})$ [%]	$\hat{relB}$ [%]	$\hat{SE}(\hat{relB})$ [%]	$\hat{B}$ [km^2]	$\hat{CV}(\hat{B})$ [%]
Tropical Forest	99.4%	0.4%	90.6%	1.5%	63.5%	8.0%	−74.1%	4.2%	2647584	14.5%
Temperate Forest	99.9%	0.1%	94.5%	2.1%	55.7%	7.9%	−87.6%	3.5%	319284	23.3%
Boreal Forest	99.9%	0.1%	27.0%	9.8%	23.9%	3.9%	−4.0%	9.1%	138031	34.6%
Tropical Savanna	99.2%	0.1%	60.7%	5.6%	35.2%	2.5%	−39.3%	7.6%	3934283	13.8%
Temperate Savanna	99.9%	0.1%	63.4%	11.8%	27.9%	7.9%	−49.2%	11.1%	370586	22.8%
Mediterranean	99.8%	0.1%	94.2%	8.2%	58.8%	10.6%	−85.9%	16.1%	124173	42.4%
Deserts/Xeric Shrublands	99.9%	< 0.1%	64.9%	6.4%	30.8%	6.0%	−49.3%	7.54%	99598	18.1%
Global	99.7%	< 0.1%	72.6%	3.9%	40.2%	2.4%	−54.1%	5.3%	7633539	8.9%

In this paper, the resolution of MODIS is also considered: the low resolution of MODIS means that, for example, a fire of 1 ha in reality would be detected as 25 ha fire due to the minimum detection area constraint related to the ground resolution.

MODIS: 500m x 500m = 25 ha

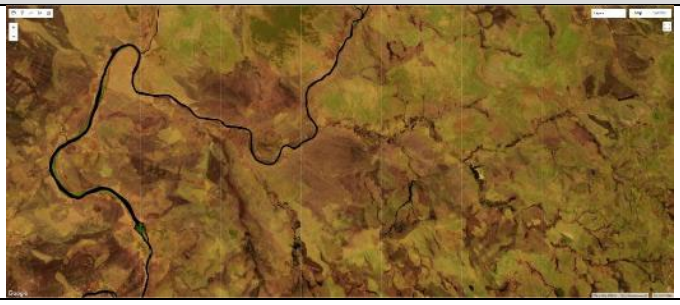
Landsat8: 30m x 30m ≒ 0.1ha

This difference suggests a large possibility that the fire area detected by MODIS is overestimated.

2.1.2.2. Accuracy verification of fire area detection by MODIS satellite (visual interpretation using Landsat 8)

The methodology used in the literature review was applied mutatis mutandis to compare the MODIS-detected fire sites with the Landsat 8 fire sites by visual decipherment.

The images in Figure 2 below are taken before the fire (No. 1) and after the fire (No. 2 and 3), both in Landsat8. In the No. 3 image, the areas where fire was detected by MODIS are shown in red, and the areas where fire was not visually legible in No. 2, but relatively large fire was detected in No. 3 are shown in pink with a dotted line. The dotted lines indicate the areas where the fire is not visually legible in No. 2 but is relatively large in No. 3. Clearly, MODIS is detecting fires over a wider area.

No	Shooting Date	satellite	image
1	2015 August 20	Landsat 8	

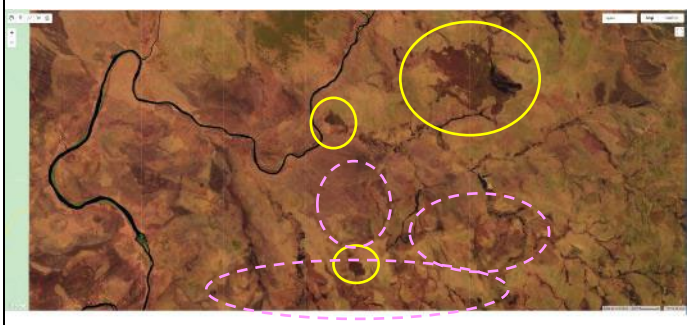
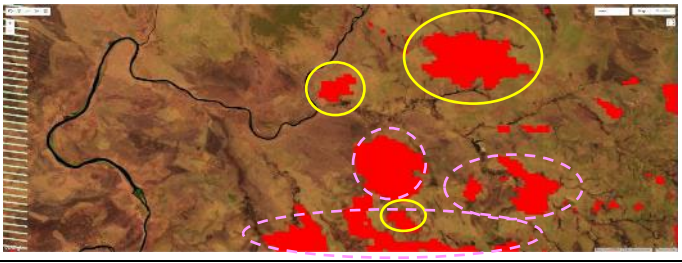
2	2015 August 27 ～ 28th	Landsat 8	
3	2015 27 ～ 28th	MODIS	

Figure 2: Comparison of MODIS-detected fire areas with Landsat images
(While some of the data within the dotted lines in the figure are underestimates, the majority are overestimates.)

The following chart (Figure 3) also shows the fire sites detected in 2019 throughout the KAZA-TFCA.

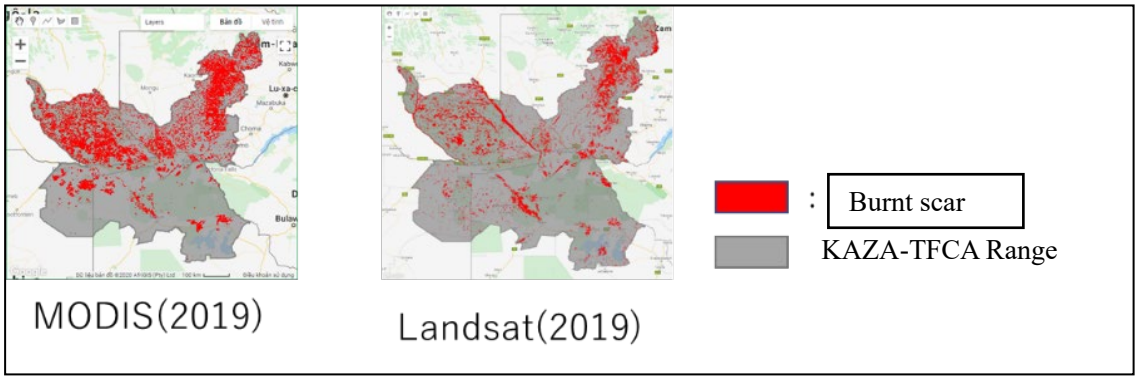


Figure 3: Fire sites detected in 2019 throughout KAZA-TFCA

Verification Result

These results suggest that the fire area detected by MODIS is an overestimated value in the Southern African region, especially in KAZA-TFCA. The results also suggest that the fire area detected by Landsat is more plausible.

Landsat will be used to further analyze the area of fire occurrence in KAZA-TFCA over the past 20 years.

2.2. Analysis of fire area in KAZA-TFCA

Since the previous study suggested that the fire occurrence detected by MODIS may be excessive, Landsat was used to analyze the area of fire occurrence in the four KAZA TFCA countries (Angola, Botswana, Namibia, and Zambia) for a total of 20 years, from 2000 to 2019. Landsat was used to analyze the area of fire occurrence in these four countries.

2.2.1. Analysis Methodology

Images taken by the following satellites are used.

From 2001 to 2014: Landsat 5 and Landsat 7
From 2015 to 2019: Landsat 7 and Landsat 8
Filter search images by cloud coverage of 30% or less
The satellite image retrieval period is set from January 1 to December 31 of the relevant fiscal year.
Satellite images that meet the above conditions are combined into a single image and organized as a cloudless image for the fiscal year.
The ground resolution is 30 meters.
The above conditions and settings were used to identify fire sites.

2.2.2. Fire area dynamics

The dynamics of fire area (km^2) over the 20-year period from 2000 to 2019 is shown in the following figure. The largest area is about 49,000 km^2 in 2002 and the smallest is 16,500 km^2 in 2019, which is more than twice as large as the previous year. It can also be seen that the fire area is alternating between increasing and decreasing trends.

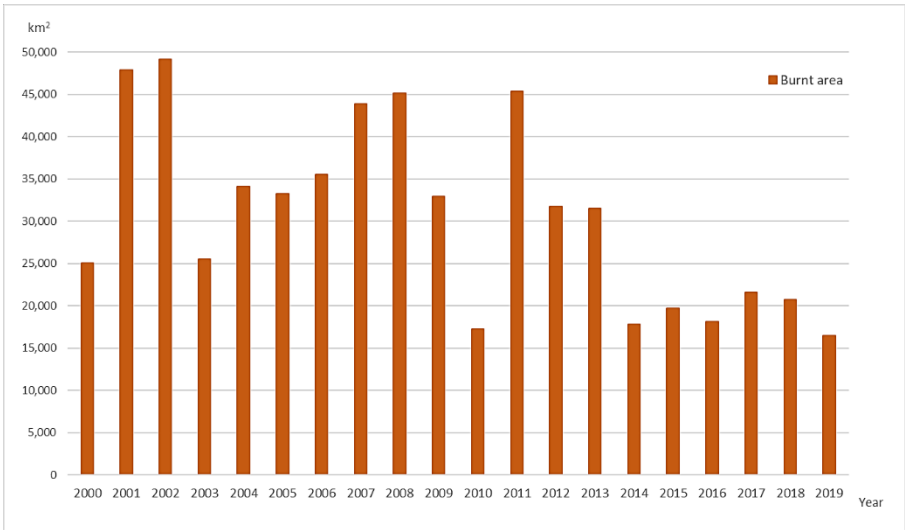


Figure 4: Fire area by year in the KAZA-TFCA region from 2000 to 2019

2.3. Analysis of fire frequency in KAZA-TFCA

The above has analyzed the area of forest fires and their trends in each year throughout the KAZA-TFCA. On the other hand, it is known that in the semi-arid forests of southern Africa, disturbances caused by repeated natural forest fires play an important role as part of the ecological cycle. In other words, the total area of forest fires in the past includes the area of forest fires that occurred repeatedly in the same location. In order to understand the characteristics of forest fires and analyze their causes, analysis based on fire frequency is necessary.

Therefore, in addition to the previous analysis of fire area dynamics based on satellite imagery, the analysis was conducted to determine the regional characteristics of areas with high fire frequency and to compare the characteristics of areas with high and low fire frequency.

2.3.1. Analysis Methodology

The satellite data used was Landsat (30 m ground resolution), the analysis of fire area was identified by an independent analysis of the collected Landsat satellites, and the period of analysis was from 2001 to 2020. Figure 5 shows the results of the analysis.

There is a wide distribution of areas where forest fires occurred more than 10 times during the 20-year period covered (the western area in the figure), and a simple average would indicate a fire frequency of once every two years.

2.3.2. Fire frequency distribution and its trend

In terms of regional distribution, fires were observed to occur frequently in Kafue and Sioma-Nguwezi National Parks in Zambia, around Mudum National Park in Namibia, and from Chobe National Park to Kasane Forest Reserve and Kazuma Forest Reserve in Botswana, Fire tends to occur more frequently in protected areas such as national parks and conservation forests. Furthermore, high fire frequency was observed in areas west of the KAZA-TFCA, where the San people of Angola and Namibia are believed to reside.

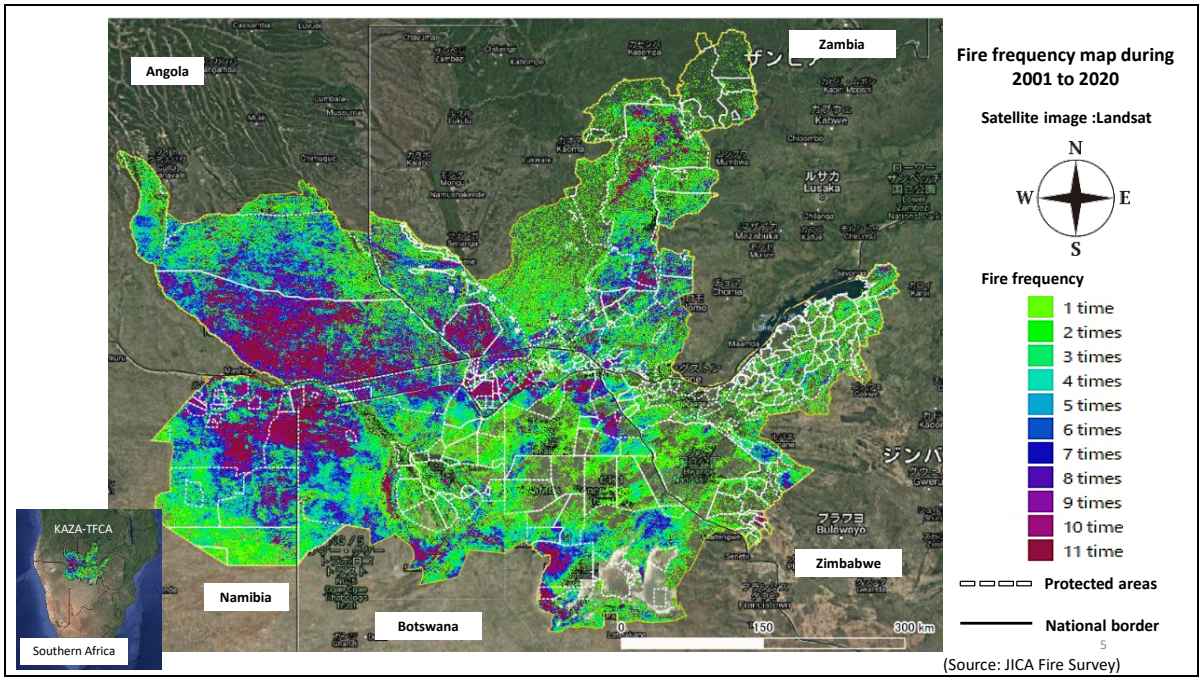


Figure 5: Map of fire frequency in the KAZA-TFCA region from 2001 to 2020

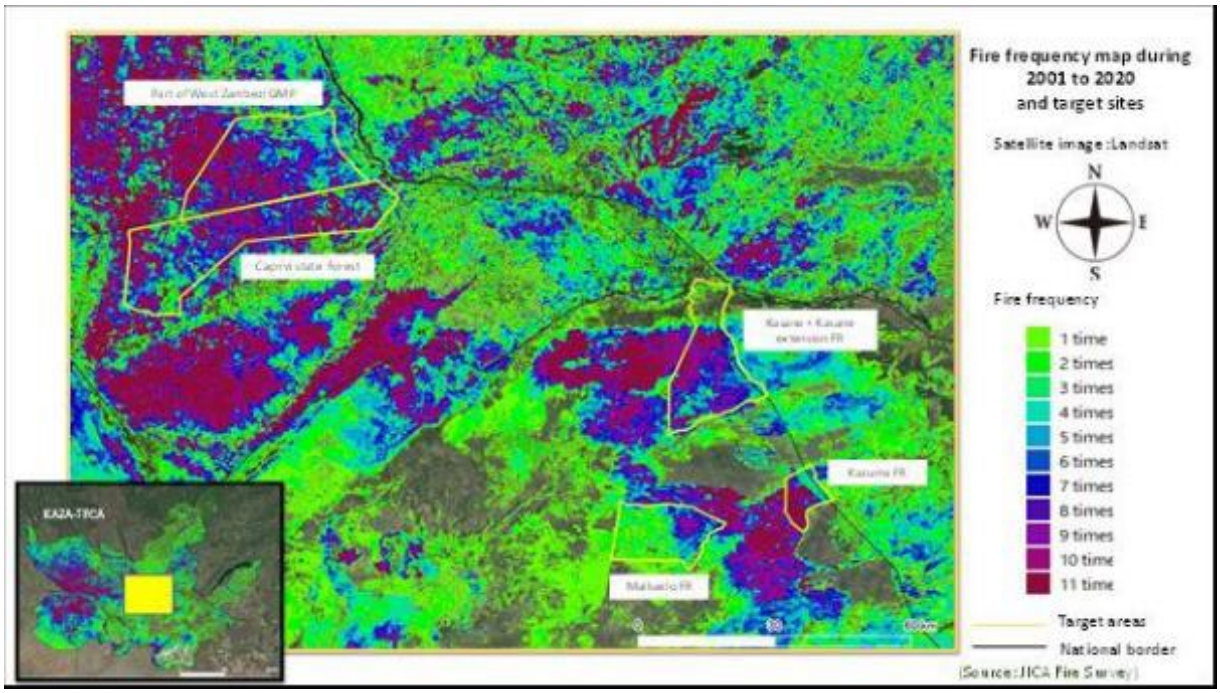


Figure 6: Map of fire frequency in the KAZA-TFCA region from 2001 to 2020 (partially enlarged)

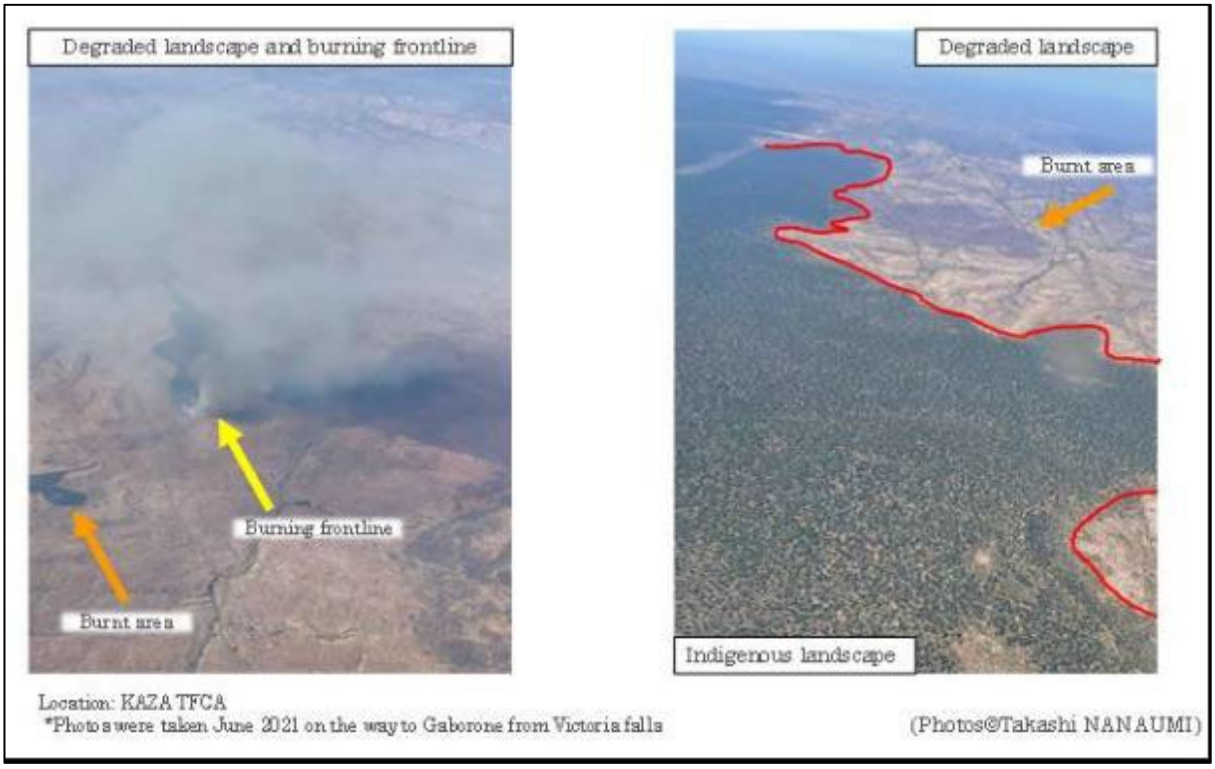


Photo 1: Aerial view of the fire and fire site taken from the sky in 2021.

Next, in order to identify trends in increasing and decreasing fire frequency from the past to the present, fire frequency distribution maps were created for three time periods: 1991-2000, 2001-2010, and 2011-2020.

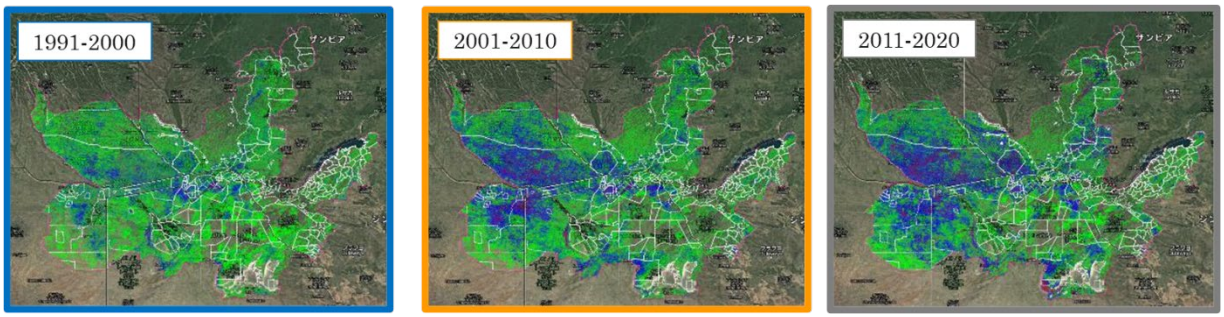
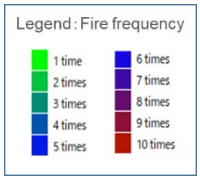


Figure 7: Fire frequency maps for three time periods



This analysis indicates that fire frequency during the 1991-2000 period was lower than in the two subsequent periods, which could be interpreted as an increase in fire frequency in recent years.

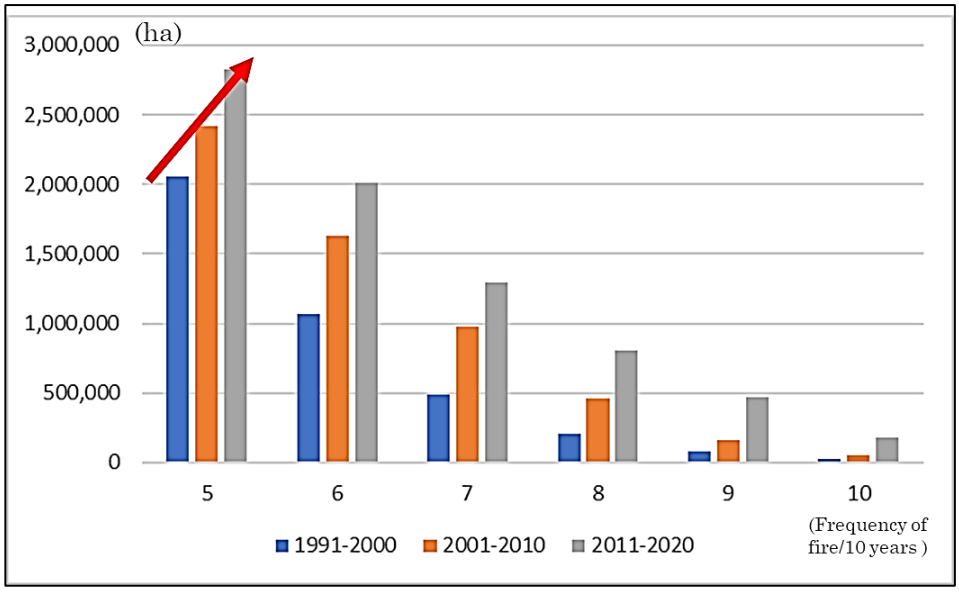


Figure 8: Fire area by three time periods and frequency

Figure 8 shows the total fire area by three time periods and frequencies. There is a steadily increasing trend in all fire frequencies, quantitatively confirming the trend observed in Figure 7.

2.3.3. Relationship between high fire frequency and vegetation

Next, we conducted an analysis to determine the land cover in which forest fires and high fire frequency areas occur.

Figure 9 shows the results of the survey team's own vegetation distribution map using Sentinal-2 satellite data.

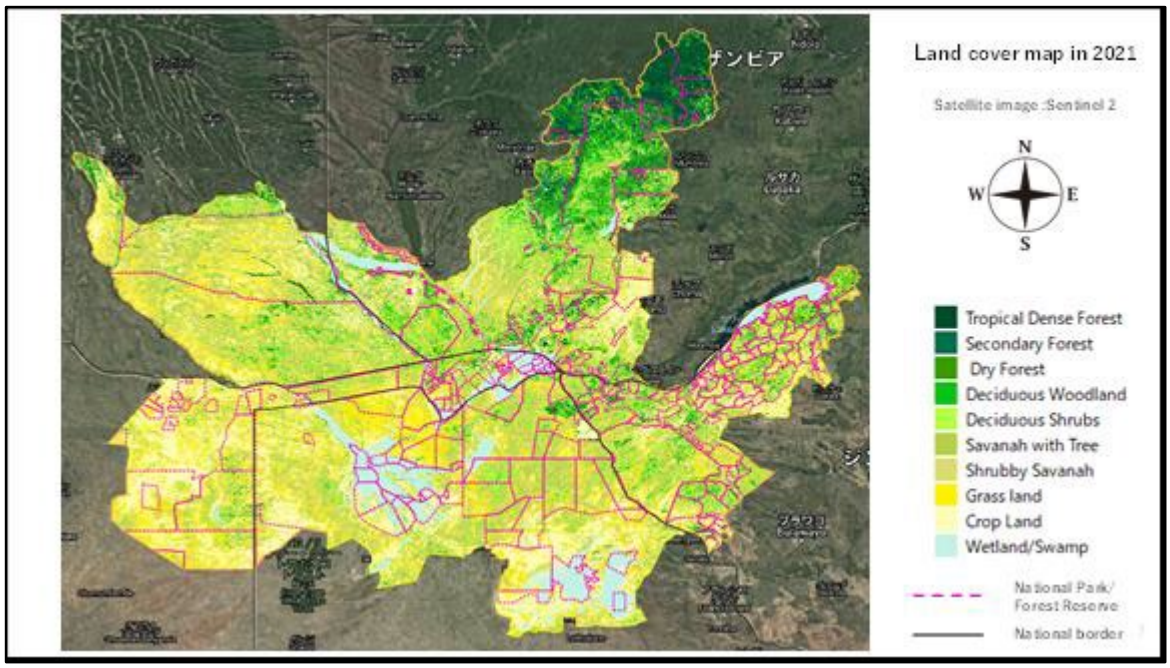


Figure 9: Vegetation map within the KAZA-TFCA (original analysis of Landsat by the survey team)

According to this distribution, tropical dense forest and secondary forest are distributed in the northeastern part of KAZA-TFCA (within Zambia), while dry forest, deciduous low shrub forest, and grassland are widely dominant in the other areas. Next, we defined "high fire frequency areas" as areas where five or more fires occurred in the same area in the fire frequency distribution (2001-2020) shown in

Figure 6 and analyzed the relationship between high fire frequency areas and vegetation by overlaying the vegetation distribution map in Figure 9.

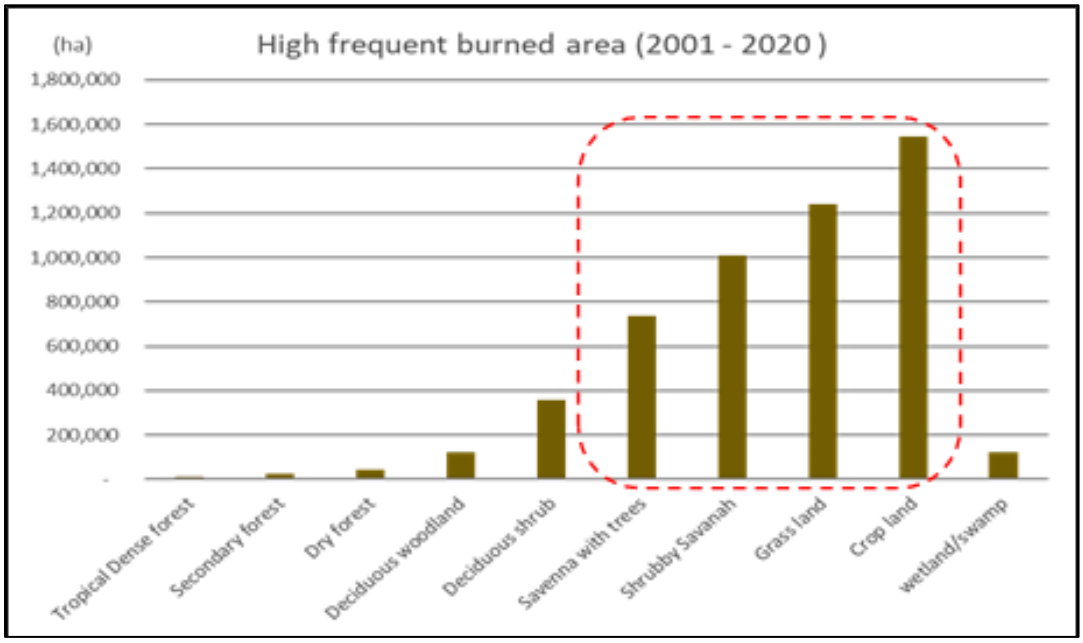


Figure 10: Relationship between high fire frequency and vegetation

It found that high-frequency fire areas included grassland savanna, low shrub savanna, grassland, and agricultural lands. Repeated fires in agricultural lands are considered to have little impact on natural resources if they are part of anthropogenic activities and proper fire management is implemented.

2.3.4. Characteristics of high and low frequency fire locations

Next, to analyze the impact of high-frequency fires on vegetation, we used Google Earth, which contains high-resolution satellite imagery of areas adjacent to the low-frequency fires being compared, to observe differences in vegetation on the ground.

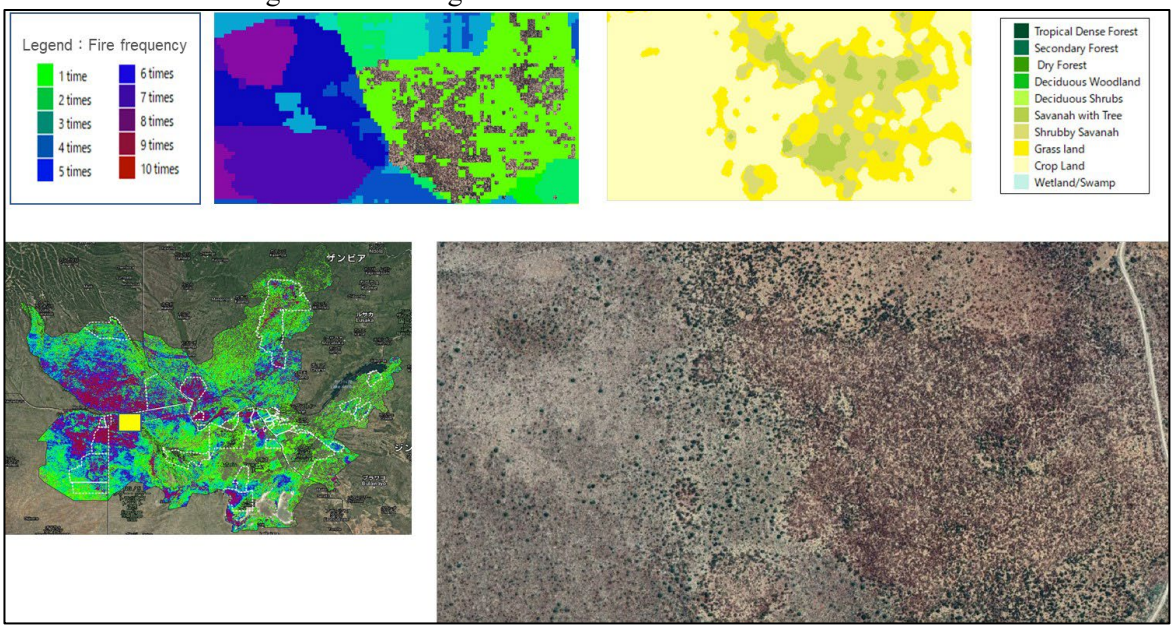


Figure 11: Differences in ground vegetation between high and low frequency fire areas (Botswana: near Shakawe village)

The above is a case study of Shakawe village area, located in northern Botswana near the Namibian border. The high-resolution satellite image of Shakawe shows a clear difference in vegetation masses between areas with five or more fires and areas with one or two fires. The high-frequency fire area is dominated by Rangeland or Grassland, with scattered shrubs and bushes. On the other hand, in the low frequency fire area, single tree canopy was clearly observed, and the density of trees was moderately high, indicating a low shrubby savanna forest.

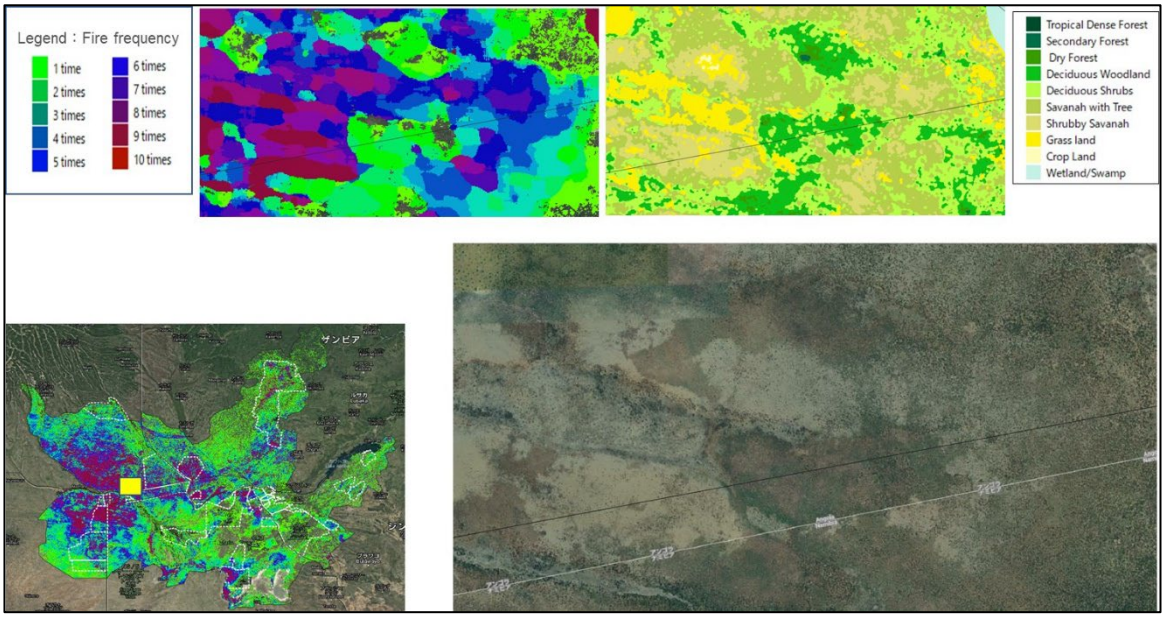


Figure 12: Differences in ground vegetation between high and low frequency fire areas (Angola: Luiana percial reserve)

It can be observed that vegetation differences between high and low frequency fire areas are more pronounced in the Angolan case than in the Botswana case shown earlier.

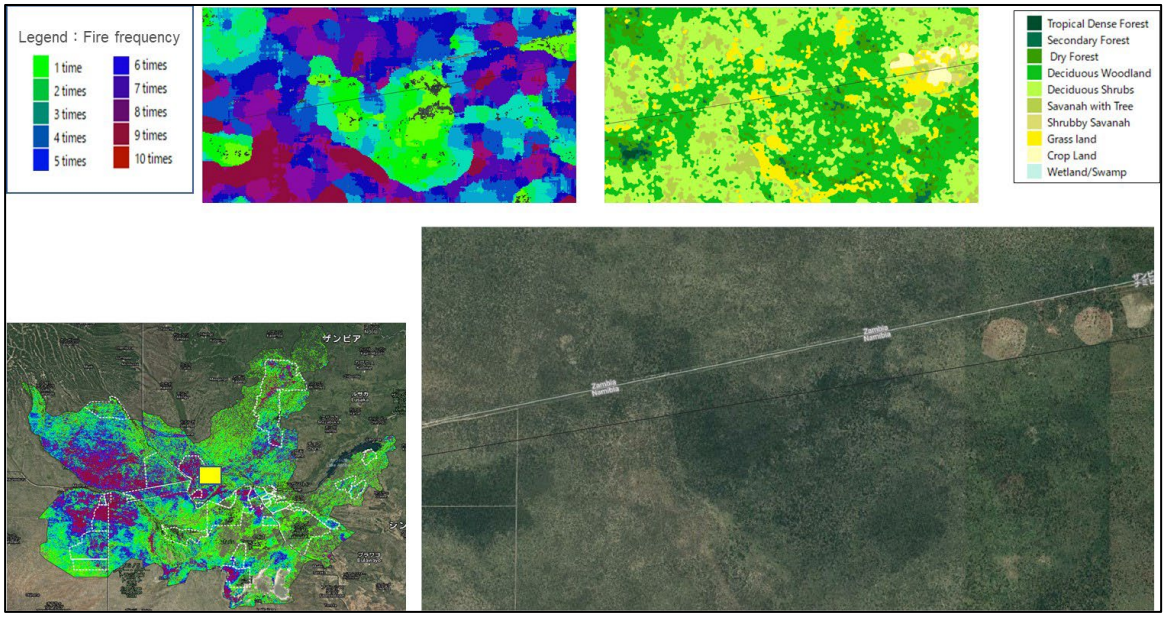


Figure 13: Differences in above-ground vegetation between high and low frequency fire areas (Namibia: Caprivi state forest)

A further case study of the Caprivi National Forest in Namibia is shown. The line traversed on the high-resolution satellite image is the main road from Namibia into the KAZA-TFCA and then to Victoria Falls on the Zambian side, and agricultural activity can be seen along the road (three circled areas on the right of the image). As in the other two areas, grasslands predominate in the high-fire areas, while low-shrub savannas are maintained in the low-fire areas.

One notable difference is that in the high fire frequency sites, the ground vegetation is maintained in Rangeland or Grass land, but in the low fire frequency sites, the canopy is clearly visible and denser than in the high fire frequency areas.

These results suggest that areas with high fire frequency may be maintained as "Grass land" due to human-caused fire, which is a limiting factor for forests that would normally have been formed through succession. This suggests that the Grass land may be a degraded area of Grassland savanna or low shrub savanna due to the effects of frequent forest fires, which could be interpreted as a degraded land cover of semi-arid forests.

This can be captured schematically in Figure 14.

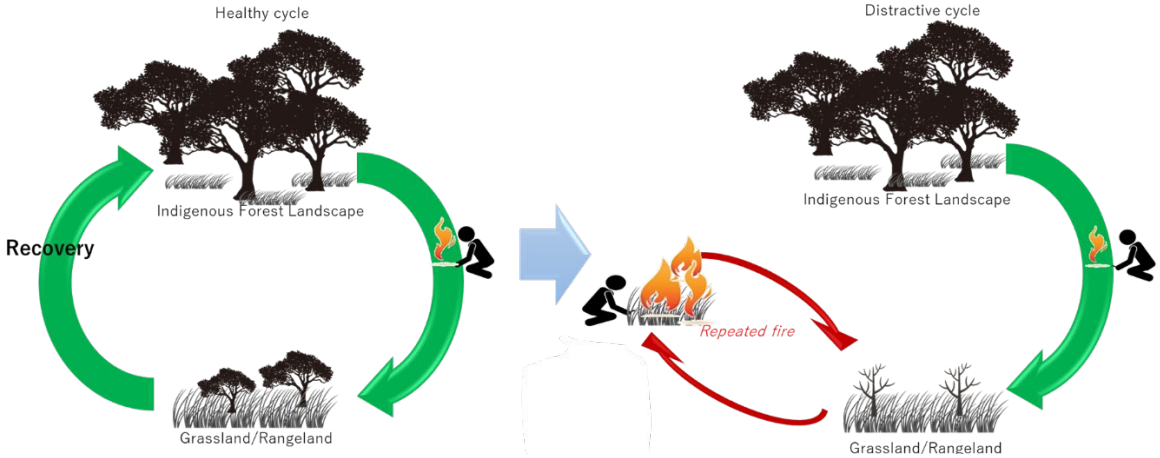


Figure 14: Ecosystem restoration processes supported by fire disturbance and the impact of anthropogenic disturbance on the processes.

The left side of the figure 14 shows the normal cycle of a semi-arid forest ecosystem supported by forest fire. After the fire, the ecosystem undergoes a transition from Grassland or low shrub forest to potential vegetation due to the restoration function of the ecosystem. On the other hand, the right side of the figure 14 shows that after the fire, before the transition to the ecosystem restoration process, the ecosystem is again disturbed by fire due to human influence, and degradation has progressed to the point where the restoration function is lost. The degradation of ecosystems themselves due to impacts beyond the resilience of the ecosystems is an international issue, and immediate countermeasures are desired in the semi-arid forests of southern Africa.

This analysis has allowed us to understand the dynamics and characteristics of forest fires and their impact on ecosystems in the KAZA-TFCA region of Southern Africa.

In the next section, in order to determine which environmental or socioeconomic factors influence the detected fire area, we will analyze the relationship between the following factors.

(1) Seasonal variation in fire occurrence
(2) Comparison with precipitation
(3) Relationship to El Niño or La Niña outbreaks.
(4) Comparison with socioeconomic factors

Since it is difficult to conduct socioeconomic surveys in the area due to the corona, data will be collected and analyzed based on statistical information that can be obtained through internet web searches.

2.4. Cause Analysis of Fires in KAZA-TFCA

2.4.1. Literature review related to the cause of the fire

When considering countermeasures based on the cause of a fire, it is necessary to verify whether the cause of the fire is man-made or naturally occurring, as typified by a lightning strike. Based on the literature, the causes were examined.

The following two papers are reported as studies of the causes of fires in the Southern African region.

1） Archibald, S. et al. (2008) What limits fire? An examination of the drivers of burnt areas in Southern Africa.

2） Philip, C. G. et al. (2018) Classifying drivers of global forest loss. Science Vol. 361 (6407), 1108-1111.

Archibald et al. (2008) examined the number of lightning strikes and fire area and found that the two were inversely proportional (Figure 15) (gray bars: number of lightning strikes; solid black line: fire area). We also found that more than 90% of the fires occur during the dry season. These results suggest that fires that occur during the dry season are likely to be human caused.

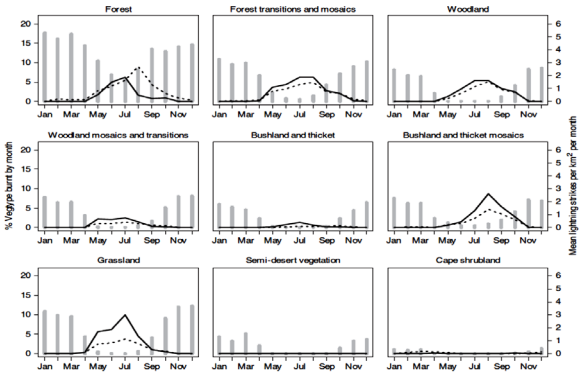


Fig. 2 Seasonal distribution of lightning strikes and burnt area in the 12 major vegetation types identified by White (1983). Grey bars show mean monthly lightning strike frequency; solid lines show the percentage of the area burnt defined by the Moderate Spatial Resolution Spectroradiometer (MODIS) burned area product (Roy *et al.*, 2005b); dotted lines show the percentage of fire-affected area defined by the 1 km MODIS active fire product (Giglio *et al.*, 2003).

Figure 15: Area of lightning strikes vs. area of fires

Philip et al. (2018) showed that the driver of deforestation in Africa is due to the expansion of agricultural land (Table 15). In the study area, the practice of burning when residents clear and cultivate forests was observed during field visits by the SADC JICA Forestry Project. This suggests that the burning associated with agricultural land clearing, especially repeated fires and associated fire spread, negatively impacts ecosystem resilience and affects the degradation of ecosystem services.

Table 15: Driver-specific trends in deforestation and degradation by region

Table 1. Disaggregation of global and regional tree cover loss by driver for the period 2001 to 2015. Map-based estimates are based on Global Forest Watch data (*3*) and a driver of tree cover loss from the current study. Sample-based estimates are based on the validation sample of 1565 randomly selected 10 × 10 grid cells from the current study. Uncertainty of sample-based estimates represents a 95% confidence interval.

	Map-based estimates							Sample-based estimates				
	Hansen *et al.* (*3*)		Current study: Driver of tree cover loss					Current study: Driver of tree cover loss				
Region	Tree cover loss (Mha, 2001–2015)	Tree cover loss (% of global total, 2001–2015)	Deforestation	Shifting agriculture	Forestry	Wildfire	Urbanization	Deforestation	Shifting agriculture	Forestry	Wildfire	Urbanization
North America	70	21%	1%	<1%	56%	40%	2%	2 ± 1%	1 ± 1%	48 ± 11%	48 ± 11%	1 ± 1%
Latin America	78	25%	56%	31%	13%	1%	<1%	64 ± 8%	24 ± 7%	9 ± 3%	<1 ± <1%	<1 ± <1%
Europe	15	5%	None	<1%	99%	1%	None	None	<1 ± <1%	95 ± 5%	5 ± 5%	None
Africa	39	13%	4%	92%	4%	<1%	<1%	2 ± 1%	93 ± 3%	4 ± 2%	<1 ± <1%	1 ± 2%
Russia/China/ South Asia	64	20%	<1%	<1%	41%	58%	<1%	2 ± 2%	1 ± 1%	38 ± 12%	59 ± 12%	<1 ± <1%
Southeast Asia	39	13%	78%	9%	13%	<1%	<1%	61 ± 13%	20 ± 10%	14 ± 6%	2 ± 6%	<1 ± <1%
Australia/ Oceania	10	3%	7%	10%	29%	53%	1%	8 ± 6%	10 ± 4%	19 ± 9%	62 ± 14%	1 ± <1%
Global	**314**	**100%**	**25%**	**21%**	**31%**	**22%**	**<1%**	**27 ± 5%**	**24 ± 3%**	**26 ± 4%**	**23 ± 4%**	**1 ± <1%**

2.4.2. Frequently occurring fire locations and analysis of their causes

From Figure 16, we verified which areas have high fire frequency (red) and are widespread. Of the high frequency areas, those marked in light blue in Figure 16 overlap with national parks. According to interviews with Namibian Forest Service officials and experts from the NGO IRDNC (Integrated Rural Development and Nature Conservation), the high frequency of fires in the area around Mudumu National Park, located in the lower left of Figure 16, is due to the following factors (1) Prescribed burning for national park management, (2) burning to promote sprouting of thatching grass, and (3) burning to promote growth of Devils claw (*Harpagophytum procumbens)*. The three possible cases were anticipated.

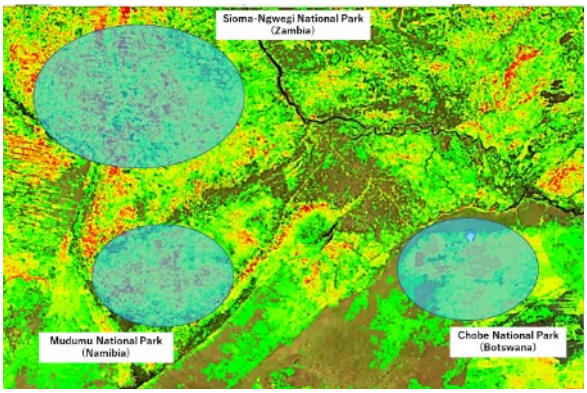


Figure 16: Areas with high fire frequency and widespread of fire

Prescribed burning is conducted by the National Park Manager to remove combustibles on the ground to prevent large fires and their spread. Thatching grass is sold in bundles for N$8-10 (Namibian dollar) per bundle. Fire is also used to prevent injury to other plants from thorns during harvesting and to make it easier to detect the Devil's claw. Devil's claw has high medicinal value, and European pharmaceutical companies in Germany and France purchase it at high prices. As a result, it has become a source of income for residents, and as of 2012, 50kg bags of Devil's claw were selling for N$850-1,000 (17-20N$/kg)[28] , but according to a news article from 2020[29] , it is reported to be selling for 45-53N$/kg.

Left: Thatching grass being sold after harvesting for N$8-10 per bunch.[30] Right: Thatching grass used for roofs of houses[31]	
Left: Devil's claw flowers[32] Right: Dried underground stem. This part is traded	

Photo 2: Non timber forest products

Since the results of previous analyses have suggested that fire spread is related to human activities involving agricultural production, we examined the relationship between fire frequency and the location of fire outbreaks near major roads that are easily accessible by humans and that can be deciphered from satellite imagery as likely to be agricultural land.

[28] JICA. 2012. Information Collection and Analysis for One Region One Initiative in Namibia Final Report. http://jp.imgpartners.com/image/NAMIBIA20 OROI.pdf

[29] The Namibian, https://www.namibian.com.na/203823/archive-read/Devils-claw-sales-skip-middleman

[30] New Era Newspaper (https://neweralive.na/posts/harvesting-and-selling-thatch-grass-for-a-living)

[31] Strohbach B. J. and Walters H. J. A. 2015. An overview of grass species used for thatching in the Zambezi, Kavango East and Kavango West Regions, Namibia. Dinteria No. 35: 12-42.

[32] Mncwangi N et al. 2012. Devil's Claw- A review of the ethnobotany, phytochemistry and biological activity of Harpagophytum procumbens. Journal of Ethnopharmacology, Vol. 143, page 755-771

Figures 17 and 18 are analytical images along the main road in Katima Mulilo, Namibia. When the images are enlarged, it is possible to see a fire that is believed to be human caused. The fire area is square in shape and overlaps with an agricultural area. This means that the fire did not spread over a large area as seen in the national park area, and it is believed that the fire was controlled within the farmland.

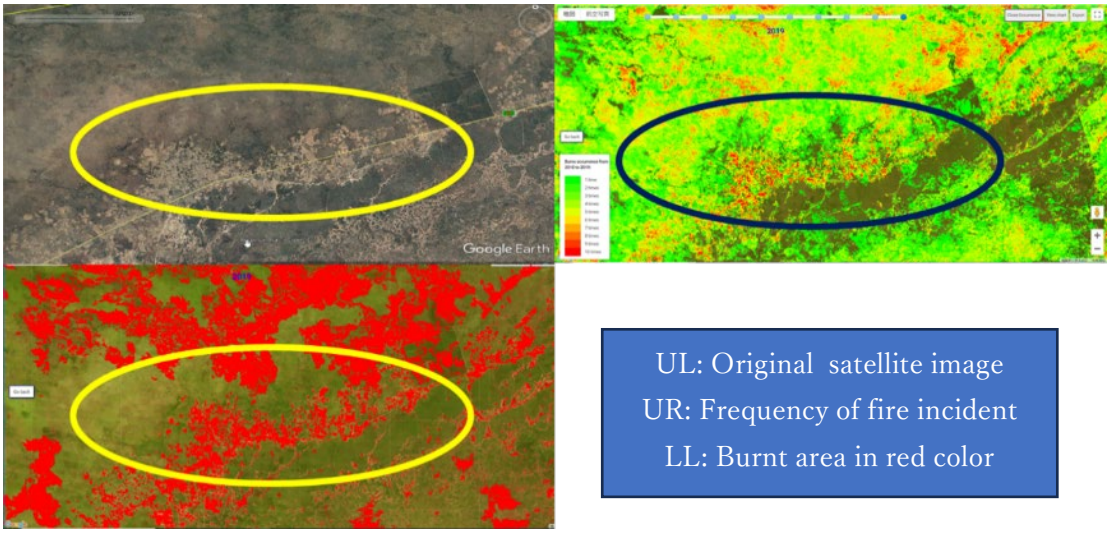


Figure 17: Fire along the main road in Namibia. The location of the fire was believed to have been set on agricultural land.

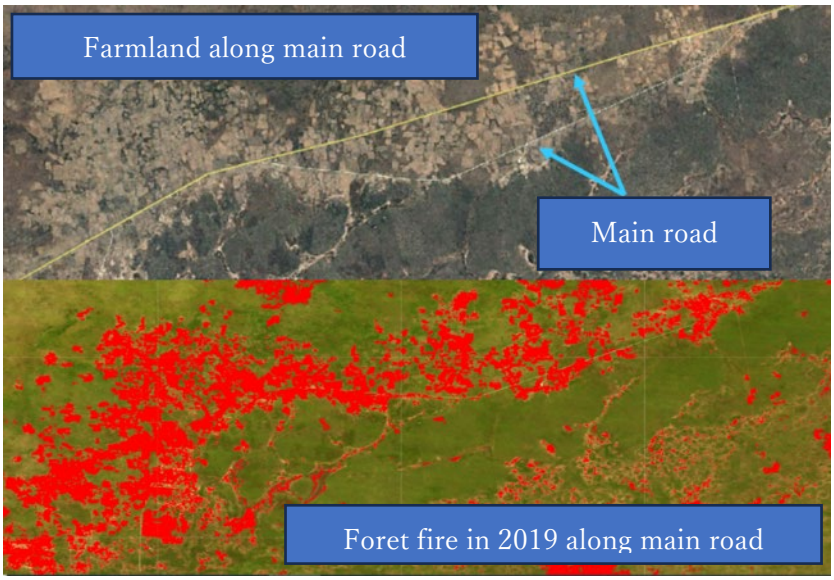


Figure 18: Enlarged images of the upper left and lower left figures in Figure 17

Figure 19 below shows the farmland area and the national park area. Comparing the two areas, it was observed that the spread of the fire in the farmland area was square shaped and controlled. In the national park area, on the other hand, it was observed that the fire spread over a wider area.

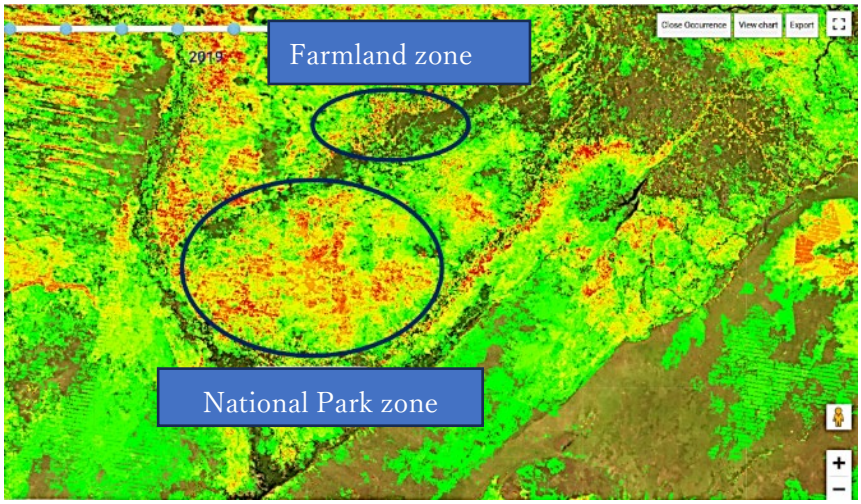


Figure 19: Comparison of the appearance of fires between agricultural areas and national park areas

Based on the previous analyses and literature review, it has been assumed that the cause of fire occurrence and spread was due to human caused burning for the purpose of expanding agricultural land. However, the following results were obtained from the analysis of fire frequency in this study.

(1) Fires in agricultural areas are controlled by fire spread within an open square area.
(2) Fires in the national park area have spread widely.

The above results may reveal the following in terms of fire control.
(1) It was confirmed that the fire caused by the expansion of farmland, which has been commonly believed, is a good fire, so to speak, because the fire area is controlled within the farmland, although the frequency of fires is high.
(2) Assuming that pre-scribed burning is a controlled fire, the bad fire, which causes uncontrolled fire to spread and impacts private land, livestock, and ecosystems, was considered to be a fire for the purpose of harvesting thatching grass and Devil's claw, which is done by the surrounding residents to generate income. Devil's claw harvesting.

This analysis suggested that the income activity of residents living near the national park may be bad fire spreading. Therefore, we planned to conduct field interviews to clarify this point. The following were the targets of the interviews that could be assumed at this point. The survey was conducted in the form of Key Informant Interviews and Focus Group Discussions.

Residents harvesting thatching grass and Devil's claw (method of burning, frequency, location, etc.)
Traditional Authority (TA) to which the resident belongs (for TA land use permits and fire burning practices)
National Park managers (for Prescribed burning, planning and fire management methods)
Forestry Department staff (in charge of extinguishing fires in forests)

2.4.3. Analysis of the relationship between fire area and climatic factors

The work performed in Figure 4 under the “2.2.2.” analyzed the 20-year trend of fire area detected by Landsat. To discuss the relationship with weather, we analyzed the relationship between precipitation and El Niño/La Niña and the area of fire occurrence.

We compared the area of fire occurrence with the available precipitation data (2001 - 2019) and El Niño/La Niña occurrence years in the KAZA-TFCA target area (Figure 20). As a result, certain trends were observed between precipitation and fire areas. The trend of fire area increases after a year in which precipitation was higher than the previous year, and after a year in which fire area was extremely small in the previous year. For example, this trend is clearly seen in the years 2008 - 2009/2010/2011: compared to

2010, the fire area in 2008 - 2009 was more than twice as large, and precipitation was higher in 2010. The following year, 2011, the fire area more than doubled compared to 2010.

In order to understand when fires occur during the year, we compared the annual area of fires with the area of fires during the dry season (November - April of the following year) in some years (Figure 21). It can be observed that more than 90% of the annual fires occur during the dry season. No relationship was observed between El Niño/La Niña and fire areas.

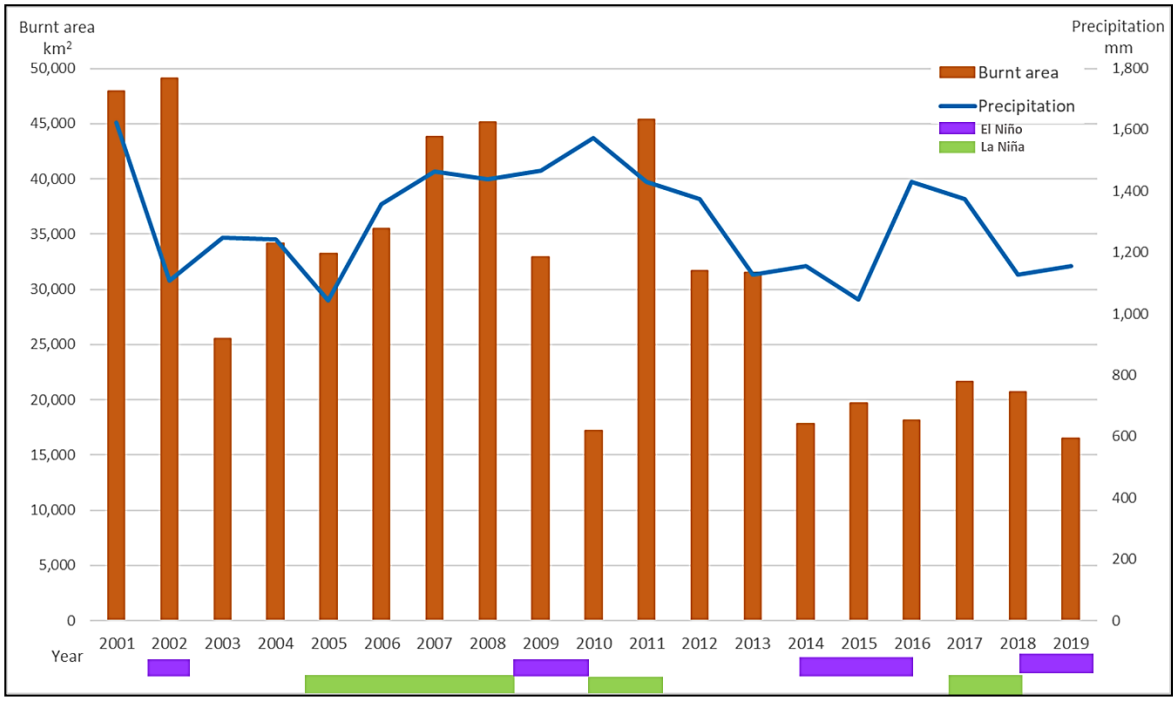


Figure 20: Fire area vs. precipitation and El Niño/La Niña

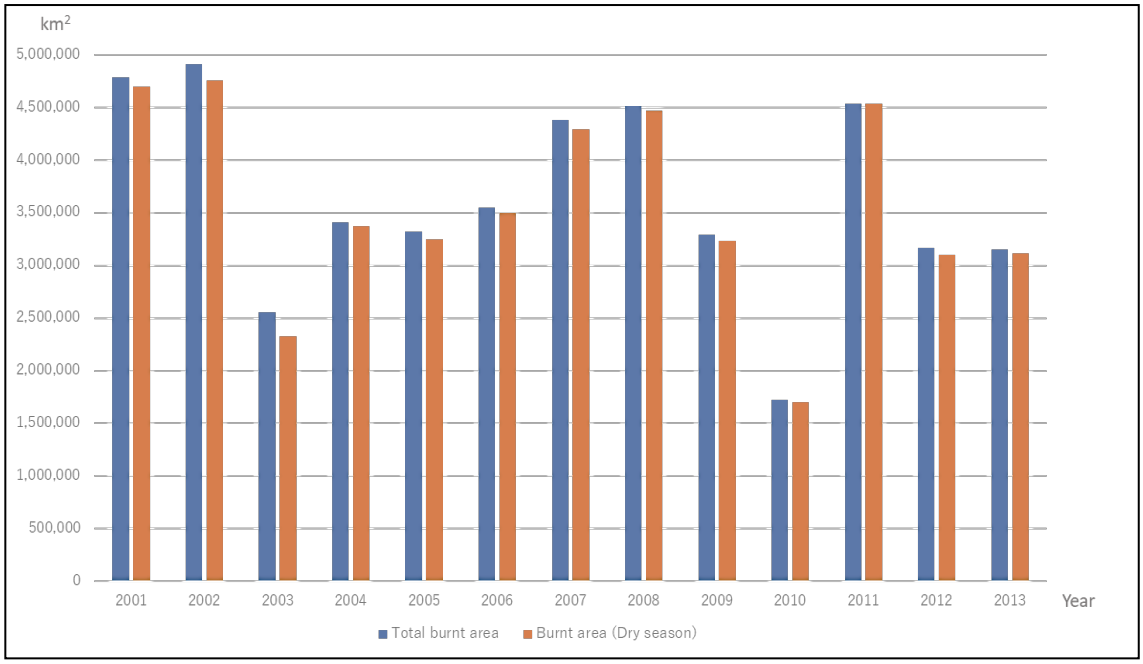


Figure 21: Annual fire area vs. dry season fire area

These results suggest that the fire spread over a wide area due to dry season burning as a result of the increased rainfall after the fire, which promoted the budding of Grassland and Woodlands, and the

accumulation of a large amount of fuel = ground combustible material on the ground, one of the three components of fire generation (fuel, oxygen, and heat).

The results of the survey to date have revealed the following points

(1) The cause of the fires is most likely anthropogenic. On the other hand, more than 90% of fires occur during the dry season, and lightning strikes occur during the rainy season, making natural (weather) factors less likely.

2) Rainfall increases the amount of combustible material on the ground, which increases the likelihood of fire spread.

Based on the above, the next section will proceed with an examination focusing on anthropogenic fire causes. Specifically, we will investigate the relationship between the price of maize and other crops, which are the main crops, and the area of fires.

2.4.4. Analysis of the relationship between fire area and agricultural commodity prices

The relationship between December precipitation and El Niño/La Niña and the area of fires was analyzed. As part of the verification of the assumption that the causes of fires are anthropogenic, we analyzed the relationship between the price of maize, which is the main agricultural crop in the region, and the area of fires.

2.4.4.1. Fire area and maze price

Comparisons were made between grain prices and fire area in Namibia and Zambia. Grain prices were obtained from FAO's FAO GIEWS FPMA Tool (Monitoring and analysis of food processes). The data for Namibia was taken from the maize price of Katima Mulilo, which is within the KAZA-TFCA region. For Zambia, the maize price at the country level was used because the price in Sesheke, the target location, could not be confirmed. Therefore, the maize transaction prices in Sesheke may differ slightly from those shown in the graph (Figure 22 below).

The dotted red line indicates that the area of fires increases as grain prices rise, while the solid green line indicates that fires are suppressed as grain prices fall. This suggests that there may be a proportional relationship between grain prices and fire area (especially in Namibia, shown on the left), but it cannot be said with certainty that this is a strong controlling factor, and confirmation through further on-site interviews and complementary surveys are needed.

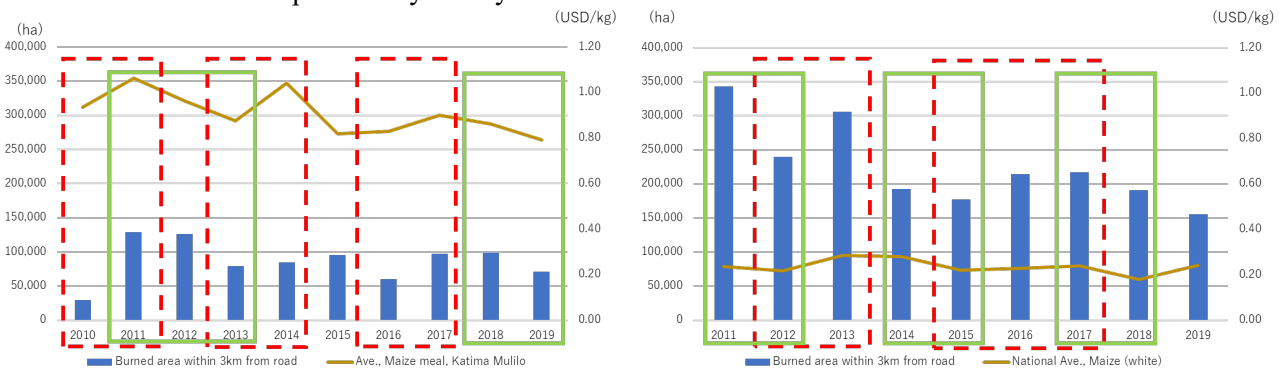


Figure 22: Annual fire area vs. dry season fire area (Namibia on left, Zambia on right)

2.4.4.2. Impact of future climate change and grain yield projections on fire occurrence

A literature review was conducted on grain yields and prices in sub-Saharan Africa.

De Pinto (2017) estimates that in the BAU[33] scenario, grain prices will increase over 40 years from 2010 - 2050 as below table 16.

Table 16: Projected Price Increases to 2050 for Three Grains

crops	Rate of price increase through 2050
maze	56~103％ (%)
wheat	24~46% (%)
comment	44~60% (%)

(Exhibit: De Pinto et al (2017))

Similarly, FAO (2018) reported that climate change will reduce cereal production and consequently the quality of people's nutritional status, estimating that cereal production will decrease by about 40% in Southern Africa; in the KAZA-TFCA region, the decrease in production of maize, a major crop, is in the KAZA-TFCA region (Schlenker & Lobell, 2010).

He also stated that grain production is expected to rise under climate change, although it has been suggested that prices are projected to rise due to the impact of reduced production on a global scale (De Pinto, 2017). In other words, assuming a proportional relationship between grain price increases and fire areas, as shown in Figure 23, higher grain prices have the potential to be an incentive for farmers to expand their cropland.

According to a report on climate change published by the Namibian Ministry of Environment in 2010, the area where rainfall seasonality will be lost by 2050 is expected to expand significantly, with negative impacts on agricultural activities. It is projected that the loss of rainfall seasonality will move the southern limit of areas where rainfed agriculture is possible northward, and that only the Zambezi Region (Eastern Kavango and Caprivi), the area covered by activities on the Namibian side of the GCF-SAP project, will be an area where rainfed agriculture is possible (Figure 23). (MET, 2010). It is suggested that in the future, rainfed agriculture in the area may become more prevalent because of climate change, and that there may be more fire burning due to population pressure on natural resources.

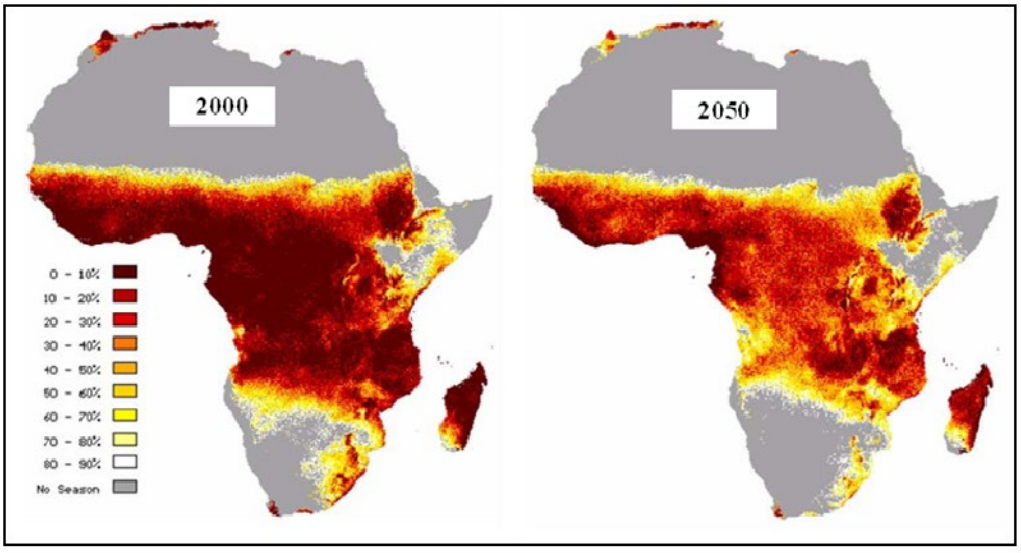


Figure 23: Probability of loss of rainfall seasonality

[33] BAU: Business as usual (when no artificial measures are taken)

2.4.4.3. consideration

The above analysis suggests the following two points.

1) Possible proportional relationship between crop prices and fire areas.
2) In the future, climate change is expected to lead to lower grain yields, higher prices, and shrinking areas where rainfed agriculture is possible.

In other words, if the fire was caused by human-controlled burning for agricultural production (good fire), it could lead to fire spread beyond the area under control (Bad fire**)**, and the forest ecosystem in the KAZA-TFCA region could be degraded by these activities in the future**.**

[Citation needed]

- De Pinto, Alessandro et al. 2017. the effects of widespread adoption of climate-smart agriculture in Africa south of the Sahara under changing climate In A thriving agricultural sector in a changing climate: meeting Malabo Declaration goals through climate-smart agriculture, eds. Alessandro De Pinto and John M. Ulimwengu. Chapter 3, pp. 22-39. Washington, D.C.: International Food Policy Research Institute (IFPRI).
- FAO. 2018. Maize markets in Eastern and Southern Africa (ESA) in the context of climate change.
- MET. 2010. Climate change vulnerability and adaptation Assessment for Namibia's biodiversity and protected area system.
- Schlenker W. and Lobell D. B. 2010. Robust negative impacts of climate change on African agriculture.

2.5. Support Needs in KAZA-TFCA

As analyzed above, forest ecosystems in the KAZA-TFCA region are facing crises such as uncontrolled fire spread and repeated fires in the same location (Bad Fire) due to an increase in forest fire area caused by reduced grain harvest and higher prices due to climate change effects.

This situation called for the development of land restoration assistance to KAZA-TFCA, with a focus on forest fire management.

The land restoration support was to be in the form of a project utilizing international funds, specifically the Green Climate Fund (GCF) and the Global Environment Facility (GEF). In particular, we applied the Simplified Approval Process (SAP) of the GCF as a template to draft a land restoration project that meets the support needs.

2.5.1. GCF-SAP Concept Note (Draft)

Refer to the attached documents.

2.5.2. GCCF-SAP Funding Proposal (Draft)

Refer to the attached documents.