南アフリカ共和国
南部アフリカにおける気候予測モデルをもとにした感染症流行の早期警戒システムの構築プロジェクト
終了時評価調査報告書

2019 年 1 月

独立行政法人
国際協力機構（JICA）
人間開発部

人間
JR
19-013

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略　語　表

略　語	正式名称	日本語
ACCESS	Alliance for Collaboration on Climate and Earth Systems Science	気候地球システム科学協力アライアンス
AMED	Japan Agency for Medical Research and Development	国立研究開発法人　日本医療研究開発機構
ARC	Agricultural Research Council	農業研究評議会
C/P	Counterpart Personnel	カウンターパート
CSIR	Council for Scientific and Industrial Research	南アフリカ科学・工学研究評議会
DST	Department of Science and Technology	（南アフリカ）科学技術省
GIS	Geographical Information System	地理情報システム
GPS	Global Positioning System	全地球測位システム
iDEWS	（Climate Prediction-based）infectious Diseases Early Warning System	（気候予測に基づいた）感染性疾患流行早期警戒システム
IHR	International Health Regulation	国際保健規則
IRS	Indoor Residual Spraying	殺虫剤屋内残留噴霧
JAMSTEC	Japan Agency for Marine-Earth Science and Technology	国立研究開発法人 海洋研究開発機構
JCC	Joint Coordinating Committee	合同調整委員会
JICA	Japan International Cooperation Agency	独立行政法人　国際協力機構
JST	Japan Science and Technology Agency	科学技術振興機構
LAMP	Loop-mediated Isothermal Amplification	LAMP 法
LDOH	Department of Health-Limpopo	リンポポ州保健局
LDOH-Malaria	Department of Health-Limpopo, Malaria Control	リンポポ州保健局マラリア予防対策センター
MM	Minutes of Meeting	協議議事録
MOU	Memorandum of Understanding	（共同研究実施にかかわる）覚書*
NDMC	National Disaster Management Centre	国家災害管理センター
NDOH	National Department of Health	国家保健省
NEKKEN	Nagasaki University Institute of Tropical Medicine	長崎大学熱帯医学研究所
NDOH	National Department of Health	国家保健省
NGO	Non-Governmental Organisations	非政府組織
NICD	National Institute for Communicable Diseases	（南アフリカ）国立伝染病研究所
ODA	Official Development Assistance	政府開発援助

* 他の JICA 技術協力プロジェクトにおける討議議事録（Record of Discussions：R/D）に相当。

略 語	正式名称	日本語
OVIs	Objectively Verifiable Indicator（s）	（プロジェクト目標や成果達成度測定のための）指標
PCM	Project Cycle Management	プロジェクト・サイクル・マネジメント
PDM	Project Design Matrix	プロジェクト・デザイン・マトリックス
SADC	Southern African Development Community	南部アフリカ開発共同体
SAMRC	South African Medical Research Council	南アフリカ医学研究評議会
SATREPS	Science and Technology Research Partnership for Sustainable Development	地球規模課題対応国際科学技術協力
SAWS	South African Weather Service	南アフリカ気象サービス
SOP	Standard Operating Procedure	標準操作手順書
TICAD	Tokyo International Conference on African Development	アフリカ開発会議（アフリカ開発における東京国際会議）
TMI	Tzaneen Malaria Institute	ザニンマラリア研究所
UCT	University of Cape Town	ケープタウン大学
UL	University of Limpopo	リンポポ大学
UP	University of Pretoria	プレトリア大学
UV	University of Venda	ヴェンダ大学
UWC	University of the Western Cape	西ケープ大学
WHO	World Health Organization	世界保健機関
WRF	Weather Research and Forecasting	領域気象モデル
ZAR	Zuid-Afrikaans Rand	南アフリカランド

終了時評価調査結果要約表

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2019 年 5 月 11 日</td><td>先方関係機関：科学技術省（DST）、国家保健省（NDOH）、気候地球システム科学応用センター（ACCESS）、南アフリカ医学研究評議会（SAMRC）、南アフリカ科学・工学研究評議会（CSIR）、国立伝染病研究所（NICD）、南アフリカ気象サービス（SAWS）、リンポポ州保健局（LDOH）、リンポポ州保健局・マラリア予防対策センター（LDOH-Malaria）、ケープタウン大学（UCT）、リンポポ大学（UL）、プレトリア大学（UP）、ヴェンダ大学（UV）、西ケープ大学（UWC）</td></tr>
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マラリアや下痢症、肺炎などの感染性疾患は、気候の変動、具体的にはラニーニャ現象などの大気海洋相互作用や気温・降雨量などの季節変動の影響を受ける可能性があることが示唆されている[1]。南アフリカ共和国（以下、「南アフリカ」と記す）を含む南部アフリカ地域ではこのような感染性疾患の危険に常にさらされている。具体的には、プロジェクト計画当時の最新のデータでは下痢症及び肺炎は南アフリカにおける 5 歳未満児死亡の上位 2 原因（それぞれ、21.4％、16.2％：2007 年）である[2]。マラリアについては他の南部アフリカ諸国と比べるとよく制御されているが、モザンビークやジンバブエなどのマラリア浸淫国に国境を接している南アフリカ北東部、特に本プロジェクトの対象地域であるリンポポ州は依然としてマラリア感染リスクにさらされている[3]。実際に、プロジェクトが開始された 2014 年には南アフリカ全体として 1 万例以上の感染者が発生している。しかしながら、気候変動と感染性疾患の発生との関係が強く示唆されていながら、その具体的な相関関係が科学的に証明されることがなかったため、気候に基づく感染症流行予測を用いた対策は今日まで実現していない。
他方、地球規模課題対応国際科学技術協力（Science and Technology Research Partnership for Sustainable Development：SATREPS）の枠組みで実施された JICA 技術協力「気候変動予測とア</td></tr>
</table>

1 A.J. McMichael, et al. Climate change and human health - risks and responses (2003)
2 UNDER-5 MORTALITY STATISTICS IN SOUTH AFRICA:Shedding some light on the trend and causes 1997-2007; *April 2012*, the Burden of Disease Research Unit, the South African Medical Research Council
3 World Malaria Report 2015, WHO

フリカ南部における応用プロジェクト」（2010-2013）は、南アフリカと日本の研究機関の共同研究により、精度の高い気候変動予測システム（SINTEX-F）を開発した。「南部アフリカにおける気候予測モデルをもとにした感染症流行の早期警戒システムの構築プロジェクト」（以下、「本プロジェクト」と記す）は、先のプロジェクトで開発した気候変動予測システムの予測性能を更に高めるとともに、特にマラリア、下痢性疾患及び肺炎について気候予測に基づく感染性疾患流行早期警戒システム（infectious Diseases Early Warning System：iDEWS）の構築と運用性の検証を目的とし、SATREPS の枠組みで 2014 年 5 月に開始された。

１－２　協力内容

（1）プロジェクト目標

南部アフリカへの適用に向けた先駆けとして、感染症対策のための気候予測に基づいた早期警戒システムモデルが確立される。

（2）成果

1）　特にマラリア、肺炎、下痢症について、気候に基づいた感染症流行予測モデルが開発される。

2）　気候予測に基づいた感染性疾患流行早期警戒システム（iDEWS）の運用指針がリンポポ州で策定される。

3）　iDEWS の予測性能と運用性が実証される。

（3）投入（評価時点）

1）　日本側：総投入額 2 億 5,000 万円

－専門家派遣：合計 3 名の長期専門家（疫学・医用昆虫学：1 名、業務調整：延べ 2 名）（101 人/月）及び合計 16 名の短期専門家（71.7 人/月）

－カウンターパート（Counterpart Personnel：C/P）研究者の来日：延べ 35 名（合計 347 日間）、研究成果の共有や研究計画の協議、シンポジウム参加等

－本邦研修：合計 7 名（気候学及び感染症学的研究にかかわる統計解析、データ管理等）

－資機材の供与：自動気象観測装置、顕微鏡や人工環境装置、マラリア診断装置などの研究機器、解析用パーソナルコンピュータ、解析用ソフトウェアなど

－在外事業強化費：国内旅費・交通費、研究用消耗品費、通信費など

2）　南アフリカ側

－C/P 配置：計 57 名（プロジェクト・ダイレクター、プロジェクト・マネジャー、研究者、行政官、技術者など）

－施設及び資機材：CSIR 及び LDOH-Malaria 内プロジェクト事務所スペース、LDOH-Malaria 内実験スペース、南アフリカ国内の全プロジェクト参画機関の既存の機器、プロジェクトに関係する利用可能なデータ、情報及び検体、CSIR 内テレビ会議システムの使用

－ローカルコスト：合計 ZAR 5,700,000（約 4,581 万 3,000 円）、リンポポ州でのフィールド調査経費、入院患者情報データベース化のための経費、南アフリカ側 C/P 国内旅費・交通費、プロジェクト活動に必要な消耗品、プロジェクト事務所水道光熱費、研究機器や試薬など本邦調達物品の輸入通関費など

２．評価調査団の概要

調査者	担当分野	氏　名	所　属
	団長・総括	金井　要	JICA 人間開発部 技術審議役
	協力企画	川口　美咲	JICA 人間開発部 保健第一グループ 保健第二チーム 調査役
	評価分析	井上　洋一	㈱日本開発サービス 調査部 主任研究員
	感染症対策研究	渡邉　治雄 （オブザーバー）	AMED 国際事業部 医療分野国際科学技術共同研究開発推進事業 プログラム・スーパーバイザー 国際医療福祉大学大学院　教授
	計画・評価	石井　克美 （オブザーバー）	AMED 国際事業部 国際連携研究課 主幹
調査期間	2019 年 1 月 8 日～2019 年 1 月 22 日		評価種類：終了時評価

３．評価結果の概要

３－１　実績の確認

（1）成果 1：おおむね達成

JAMSTEC は CSIR と協力しながら新型の大気−海洋結合モデルを用いた短期気候変動予測システム（SINTEX-F2）の開発に成功し、南部アフリカの気候予測の精度が大幅に向上した。また、SINTEX-F2 による地球規模季節予測情報の局地的高解像度化（ダウンスケーリング：約 $10km^2$程度）にも成功している。また、UP も独自のアンサンブル予測による気候変動予測システムを開発し、その後、予測のダウンスケーリングにも成功した。これらの技術は以下に示す感染症流行予測モデルのすべてと組み合わせて活用されている。

マラリアについて、熱研及び JAMSTEC はそれぞれ非線形統計モデル及び機械学習を基にした流行予測モデルを開発し、実際のマラリア予防対策への適用に十分な流行予測精度（予測値と実測値の相関係数が 0.7 以上）を示している。過去に遡っての検証ではあるが、約 20 年ぶりの大きなマラリア流行となった 2016/2017 年流行シーズンのマラリアの流行を予測できており、翌 2017/2018 年シーズンは同程度の流行規模となることを将来予測で的中させている。また、UP も十分に実用レベルの予測精度をもつ独自のアンサンブル気候変動予測システムに基づいたマラリア流行予測統計モデルを開発し、予測精度も実用レベルであることが確認されている。これらのモデルはそれぞれ異なる特徴を有し（予測のリードタイムや予測期間など）、これらを組み合わせて予測情報を作成することで、より事前対策等の計画が効果的、効率的に実施できる可能性がある。

このように、マラリアについては気候予測に基づいた流行予測モデルは、実用レベルの予測性能である。下痢症についてもモデル開発の見通しが得られ、開発作業は iDEWS 事務局の下で確実に継続されることになっていることから、プロジェクト終了後 2～3 年程度で開発作業が完了できる見込みである。肺炎についてはモデル開発が技術的に困難であることが明らかとなったが、今後の研究活動に重要な経験と知見を与えたといえる。また、プロジェクト全体で得られた研究成果は終了時評価時点で 44 報が国際誌に発表されている。したがって、成果 1 は研究協力の観点からはおおむねその目的を達成したと考えられる。

（2）成果 2：おおむね達成

警戒情報の発令基準について、当初はマラリア・アウトブレイクの早期検出に基づく警戒情報の発令によるアウトブレイク発生予防や早期封じ込めのための対応実施を行うことを想定していたが、流行予測の特性やモザンビーク等のマラリア高侵淫国と比較すると患者数の少ないリンポポ州での運用を考慮し、個別のアウトブレイク警戒情報を発令するのではなく、原則的には定期的な流行予測情報を発表し、運用指針等に従った対応を行うことを関係者間で合意している。プロジェクトは非線形統計モデル及び機械学習に基づくマラリア流行予測モデルを開発したが、それぞれの予測性能にかかわる特徴を加味した警戒情報の構築が検討されている。

また、2017 年 1 月に発足した iDEWS 導入準備委員会は研究機関だけでなく、感染症流行予測情報の実際のユーザーである LDOH や将来の制度化等をめざすうえで重要な NDOH や SAWS、NICD などの国レベルの機関が参加している。この準備委員会の下で、2017/2018 年シーズン前（2017 年第 4 四半期ころ）に実際にリンポポ州でマラリア流行予測性能の検証や、予測結果に基づく介入など運用の検討がなされた。その結果、すべてのメンバー機関は気候予測に基づいた流行予測モデルの予測性能を実用レベルと評価し、iDEWS 事務局の設立に向けた関係機関間の合意に結びついた。上記の試験導入によって運用指針の策定には更に経験を積む必要性が確認されたため、プロジェクト期間内には完成できないが、検証作業は iDEWS 事務局の下で着実に実施される見込みである。

以上のことから、十分な経験と根拠に基づいた iDEWS 運用指針がプロジェクト期間終了後数年以内には着実に完成することが見込まれるため、成果 2 もその目的は満たされたと見なすことができる。

（3）成果 3：おおむね達成

上記のとおり、プロジェクトは 20 年ぶりの大きなマラリア流行が起こった 2016/2017 年流行シーズンのマラリア患者数を流行予測モデルが高い精度で予測できることを確認し、翌シーズンは予測情報を実際のリンポポ州でのマラリア予防対策へ適用した。その結果、介入によりマラリアによる死亡率が低下した可能性を示す結果が得られ、患者数も予測値よりも若干減少していた。しかしながら、予測情報に基づく介入の効果を証明するためには、隣国からのマラリアキャリアの流入などさまざまな要因を考慮してより正確な解析を行う必要がある。

下痢症についても流行と気候変数及び気候現象との間に相関性が確認され、終了時評価時点ではモデル化に向けた具体的な検討が開始された段階である。したがって、下痢症については予測性能と運用性の評価をプロジェクト期間内に実施することはできないが、こちらもモデルが完成次第、iDEWS 事務局の下で実施される見込みである。

以上のことから、マラリア及び下痢症については、モデルの予測性能、運用性が iDEWS 事務局の下で検証され、プロジェクト期間終了後数年以内には着実に iDEWS として完成することが見込まれるため、成果 3 もその目的はおおむね満たされたと見なすことができる。

（4）プロジェクト目標：おおむね達成

これまでの日本側研究機関、南アフリカの研究機関及び行政機関の努力により、南部アフリカ地域の短期気候変動予測システムは高精度化され、さらにダウンスケーリングも成功した。この結果を基に、プロジェクトは実用レベルの予測性能を有する 3 つのマラリア流行予測モデルを開発し、これらの予測情報に基づいた実際の予防対策が試験的に実施され、その効果や課題（予測情報に基づいたマラリア流行予防対策の実施にかかわる運用ガイドラインの作成と利用できる人的・財政的リソースを考慮した最適化、展開に向けたパッケージ化の必要性など）も確認されている。

南アフリカ側研究機関、行政機関はこれまでの成果を高く評価し、iDEWS 事務局を設立し、気候変動予測を基にした、特にマラリアの感染症予測サービスを将来的に実際の行政サービスの一部とするための具体的な取り組みを開始している。さらに、終了時評価時点でプロジェクトの研究機関は気候学研究、感染症研究グループともモザンビークとの共同研究を開始しており、今後、モデルの予測性能は一層向上するものと考えられる。

さらに、マラリアに関しては南部アフリカ開発共同体（Southern African Development Community：SADC）の下でマラリア排除に向けて南部アフリカ 8 カ国によって 2007 年に設立された“Southern Africa Malaria Elimination 8 Initiative”（以下、“Elimination 8”と記す）との協力も具体化しつつあり、南部アフリカ地域への展開も大いに期待できる。

なお、下痢症については前半の活動の遅れもあってモデル化までは到達できていないが、iDEWS 事務局の下で開発作業は継続されることとなっている。肺炎については気候変動予測に基づく流行予測モデルの開発を適用することが技術的に困難であることが確認されたが、その判断に至るまでの検討プロセスは、これから他の疾患への適用を検討する際の重要な基礎情報を与えたと考えられる。

このように、南部アフリカへの適用に向けた先駆けとして感染症対策のための気候予測に基づいた早期警戒システムモデルの確立（プロジェクト目標）は数年以内には着実に達成できる見込みである。また、上記のように学術的観点、ODA 技術協力の観点の両方で大きな成果が確認されており、現時点での課題も適切に整理されていることから、終了時評価時点で本プロジェクトはその目的をおおむね達成できたものと見なすことができる。

３－２　評価結果の要約

（1）妥当性

プロジェクトの妥当性はこれまで高く維持されている。

南アフリカを含む南部アフリカ諸国では、感染症は依然として脅威である。南アフリカでは近年は感染症による死亡が減少傾向にあるものの、下痢症及び肺炎は依然として 5 歳未満児の死亡原因の上位を占める（それぞれ、8.7%、16.9%：2015 年）。

マラリアについては他の南部アフリカ諸国のなかでは比較的よく制御されているが、モザンビークやジンバブエなどのマラリア浸淫国に国境を接している南アフリカ北東部、特に本プロジェクトの対象地域であるリンポポ州は依然としてマラリア感染リスクにさらされている。実際に、2016 年は報告数が 4,323 件、死亡者数が 34 件と排除に近いレベルと考えられていたが、2017 年の報告数は前年の 5 倍以上の 22,517 件、死亡者数も 274 件と約 8 倍となった。翌 2018 年も同程度の大きな流行が起こっており、南アフリカは依然

としてマラリアのリスクにさらされているといえる。このような状況において、NDOH は「戦略計画 2015-2020」のなかで感染症対策の強化を国家プログラム「一次医療サービス」に位置づけ、感染症サーベイランスシステムの強化や国際保健規則（International Health Regulation : IHR）に沿った公衆衛生上の緊急事態への備えと対応能力強化、関連する科学技術開発を推進するとしている。さらに、将来的に南部アフリカ地域に展開することを想定し、これまで協働でモデル開発を進めてきた研究基盤のある南アフリカをパートナー及び対象国とすることで妥当性も担保されている。

他方、わが国の ODA 方針においても感染症対策を重要視しており、2013 年 6 月の第 5 回アフリカ開発会議（TICAD V）で合意された「横浜宣言 2013」の具体的施策となる「横浜行動計画 2013-2017」でも感染症対策の重要性が改めて示されるとともに、気候変動に対する取り組みを他セクターで行うことの重要性も示されている。2016 年 8 月に実施された TICAD VI で採択された「ナイロビ宣言」では「横浜宣言」及び「横浜行動計画」は 2019 年の次回 TICAD まで有効であることが確認されている。さらに、WHO は地球温暖化などの気候変動が感染症など人の健康に対する影響について対策の必要性を明確に示している。特に"WHO Global Programme on Climate Change & Health"（2016）のなかで気候変動と健康に関する科学的根拠を得ることの重要性を示している。したがって、本プロジェクトを通じて気候変動とマラリア、肺炎、下痢症との相関関係や気候変動に基づいた感染症流行予測モデルの開発、予測情報に基づく行政的な対応などに関する科学的分析は、このような国際的要求にもかなうものと考えられる。

以上のことから、南アフリカ・日本国側双方の研究機関の技術力向上や根拠（研究成果や新規知見など）に基づいた感染症対策を行う本プロジェクトの目的と南アフリカの保健政策、科学技術政策並びにニーズとの一致性は更に高まったといえる。

（2）有効性

プロジェクトの有効性は高い。

プロジェクトはこれまで短期気候変動予測システムの開発・改良とダウンスケーリングを中心とした気候学的研究に関する学術論文を数多く第一線の査読のある国際誌に発表している。気候予測を基にした感染症流行予測モデル等に関する研究成果はこれまでに数報程度であるが、終了時評価時点ではさまざまな特徴を有する 3 つのマラリアの流行予測モデルが開発され、いずれも実用レベルであることが確認されている。今後はこれらモデルによる予測情報の実際のマラリア予防対策への適用が科学的視点をもって実施、効果検証が行われる予定であることから、今後関連する研究成果がプロジェクト期間終了後も数多く国際誌等に発表されることが見込まれる。

他方、本プロジェクトは他の開発途上国との国際共同研究とは異なり、イコールパートナーとして非常に高いレベルで技術協力、技術交流が継続され、双方、気候変動に基づく感染症流行予測モデルの開発や、実際の予防対策への適用など未知の領域に挑み、プロジェクト開始前はまったくなにも実績がないところから、終了時評価時点では研究成果の社会実装が大いに期待できる成果を得ている。このことは南アフリカ・日本国側双方の研究機関、行政機関、保健機関など関係機関が大きく能力を向上させたと考えられ、本プロジェクトは ODA の視点でも大きな成果を上げたと考えることができる。

計画した3つの対象疾患に対してiDEWSを構築できてはいないものの､学術的にもODA技術支援の観点でも本プロジェクトの達成度は非常に高いと考えられ、本プロジェクトの有効性はおおむね高いと認められた。

（3）効率性

以下に示す理由により、プロジェクトの効率性は中程度である。

本プロジェクトは、2014年5月に行われた南アフリカ総選挙の影響により、南アフリカと JICA との実施機関合意文書の署名に想定よりも時間を要し、南アフリカに駐在する 2名の長期専門家の着任が同年 10 月となったため、研究機器の導入等に若干の遅延が生じた。また、南アフリカ側研究機関間の共同研究実施のための覚書（Memorandum of Understanding : MOU）締結に想定以上の時間を要し、気象地上観測データの入手などに遅延が生じた。さらに、南アフリカ側の病院入院データのデータベース化のための予算が利用できるようになるのが 2016 年に入ってからとなったため、下痢症の流行予測モデル開発におおむね半年～1 年程度の遅延が生じ、結果的に終了時評価時点で完成することができなかった。

しかしながら、プロジェクト運営としては終了時評価までに実施された合同調整委員会（Joint Coordinating Committee : JCC）に加え、南アフリカ・日本国側の双方で実施されたシンポジウムの機会及び日常的な email や電話会議等で研究の進捗や成果創出状況の管理はおおむね適切に実施されてきたと考えられる。このことは、これまでの有効性の項で示したとおり、プロジェクト活動としては半年から1年程度の遅延が認められながらも、終了時評価時点で多くの研究成果を創出していることで説明できる。遅延の原因はプロジェクト外部の要因であったが、特に南アフリカ側 C/P は活動予算確保や iDEWS 組織化に最大限の努力を行っており、供与機材や本邦研修などの投入も適切に実施されたことから、プロジェクト管理自体はプロジェクト期間を通して適切に実施されたと考えられる。

（4）インパクト

プロジェクトの実施によって、以下に示す正のインパクトが確認または期待されている。

プロジェクトで改良を行った気候予測モデルは、既にモザンビークの気候予測が可能であり、プロジェクトで開発した現在のマラリア流行予測モデルを用いてモザンビークの流行予測を行うことは技術的に可能である。プロジェクトは気候学グループ、感染症対策グループともにモザンビーク当局との協力、共同研究を開始しており、今後、本プロジェクトの成果に基づいたモザンビークへの裨益が見込まれる。他方、“Elimination 8”は気候予測に基づくマラリア流行予測のメンバー国での適用に大きな関心を示しており、終了時評価時点では具体的な協力の方法等に関する協議が開始されている。同“Elimination 8”イニシアティブを通じて南部アフリカ各国との協力が開始できれば、それぞれの国のマラリア流行データも収集、検証することで、気候予測に基づいた流行予測モデルを大きく展開できる可能性は高いと考えられる。

しかしながら、南アフリカの他州や隣国への適用を実現するには、マラリア流行予測情報に基づいた予防対策に対するひとつひとつの介入の効果についてエビデンスを構築し、

そのエビデンスを基に現場の利用可能なリソース（人材、予算等）を考慮しながら、最終的には運用指針の最適化を行うことが求められる。さらには、その最適化された運用指針に則った予測情報に基づいた予防対策が、どれだけ患者数や死亡者数に影響を及ぼしたかについて科学的に検証し、包括的なエビデンスを構築することが必要である。これが実現できて初めて他の地域や近隣国への展開が行えるようになると考えられる。

このほかにも、①南部アフリカの降水量の 10 年規模変動とマラリア患者数の関連性の発見[4]、②ザニンマラリア研究所（Tzaneen Malaria Institute : TMI）の機能強化、③iDEWS 開発をプラットフォームとした分野横断的関係者間連携など、プロジェクトによる正のインパクトが確認または期待されている。

（5）持続性

プロジェクトによって生み出された便益の自立発展、自己展開は一定程度見込まれる。

1）　政策・制度的側面

南アフリカにおいて気候変動予測モデルや感染症流行予測モデル開発の技術力を高めながら、関連した研究成果に基づいた（根拠に基づく）感染症対策を行うことの政策的重要性はプロジェクト期間終了までのみならず、終了以降も継続することが強く見込まれる。これは、NICD や SAWS などの国家機関がまもなく設立予定の iDEWS 事務局をリードすることが合意されている点でも説明できる。また、南アフリカ側関係機関はプロジェクトで開発した気候予測を基にしたマラリア流行予測情報は、実際のマラリア予防対策への適用に十分な実用レベルに達していると評価し、終了時評価時点で具体的に iDEWS 事務局の設立に向けた取り組みを行っている。当面はプロジェクト終了後 2 年間で運用指針の最適化を行い、iDEWS のマラリア予防対策に対する効果に関するエビデンスを構築する予定である。その後は構築したエビデンスを関係当局に提示し、最終的には iDEWS 事務局を行政機関の一部とすることをめざしている。したがって、本プロジェクトの政策的持続性は終了時評価時点においても一定程度期待できる。

2）　財政的側面

南アフリカ・日本国側双方の研究機関の研究能力は高く、本プロジェクトによって実用化に近いレベルに達した気候予測に基づいた感染症流行予測モデル開発や、予測情報に基づく介入等にかかわる研究はおそらく世界をリードしていると考えられる。また、南アフリカ側は、プロジェクト期間中に現地活動費として DST や ACCESS から多額の投入を行っており、それぞれの機関がこの分野で外部の競争的研究資金等を獲得できる能力は高いと考えられる。他方、上述のとおり iDEWS が南アフリカの感染症対策システムの一部となれば、行政システムとして継続運営のための予算は担保されることが見込まれる。また、プロジェクトは iDEWS が将来的には南アフリカの他州や隣国で適用されることを念頭においていることから、予測モデルに加えて運用指針、新規導入や運用コスト分析なども含めたパッケージ化に向けた取り組みが iDEWS 事務局の下で継続的に実施されることが望ましい。

3）　技術的側面

[4] プロジェクトで改良した SINTEX-F2 によって南部アフリカの降水量に 10 年規模の変動があることを発見し、これが更にマラリア患者数にも一定の相関関係があることを発見した。

南アフリカ・日本国側双方の研究機関の能力は高く、プロジェクト期間終了後もプロジェクトで獲得した新規の研究能力は更に向上することが強く見込まれる。なお、熱研、JAMSTEC はプロジェクト期間終了後も南アフリカ側プロジェクトメンバー機関との共同研究、協力活動を継続する意向を示しており、iDEWS 事務局に対しても何らかのかたちで参加もしくは協力することになっている。また、プロジェクトでは 3 つの異なる予測性能特性を有する気候予測に基づくマラリア流行予測モデル（JAMSTEC による機械学習を基にしたモデル、熱研による非線形統計モデル、UP による線形統計モデル）が実用レベルに達している。これと並行して、JAMSTEC 及び UWC は数理モデル（それぞれ、VECTRI モデル、コンパートメント・モデル）を基にしたマラリア流行予測モデルの開発を行っている。終了時評価時点ではこれら 2 つのモデルは実用レベルに達していないが、数理モデルを基にした感染症流行予測モデルは他の地域への高い適用性が期待できることから、プロジェクト期間終了後も引き続き開発作業が継続されることが見込まれている。ただし、予測情報に基づいた予防対策の介入効果の検証や、検証結果に基づいた運用ガイドラインの最適化等はプロジェクト期間終了後に iDEWS 事務局の下で継続される見込みであるが、これらの活動を実施するためには公衆衛生学的研究もしくは実務の専門性を有する人材の協力を得る必要がある。

３－３　効果発現に貢献した要因

（1）計画内容に関すること

特になし。

（2）実施プロセスに関すること

本プロジェクトには実施機関だけで非常に多くの機関が参加しているが、気候変動予測モデル開発にかかわる研究グループ、感染症流行予測モデル開発にかかわる研究グループともに、email や電話などを通して頻繁に連絡、協議等が行われている。このことによって遠く離れた南アフリカと日本で共同研究が順調に実施され、上述したような研究成果が得られた。また、プロジェクトは協力期間の前半に気候予測、感染症対策にかかわる国レベルの機関を戦略的にメンバーとしたことにより、将来の社会実装に向けた実施体制の強化が図られた。これらは、プロジェクトの有効性を高めたと考えられる。

３－４　問題点及び問題を惹起した要因

（1）計画内容に関すること

中間レビュー時には、予測情報に基づいたマラリア流行の予防対策実施を効果的かつ効率的に実施するために関連する専門性を有する JICA 専門家の投入を提言したが、実現しなかった。そのため、2017/2018 年マラリア流行シーズンの予測情報に基づいた試験的予防対策の実施は、十分な根拠や検討に基づいた介入とはならなかった可能性がある。

提言に基づいた効果的な投入が実現しなかったことにはさまざまな要因が考えられるものの、本件は効果的な投入による活動成果の最大化が一定程度阻害されたとも考えられるため、効率性の阻害要因と考えることができる。

（2）実施プロセスに関すること

病院入院情報の電子化とデータベース化については、南アフリカ側の投入で実施されることで合意していた。紙ベースの入院情報約 28,000 件を電子化し、更にデータベース化するためには相当な労力が必要であり、そのための外注費の分配が必要であったが、南アフリカ側でその予算が使用できるようになるまでに予想以上の時間を要した。このことにより、肺炎及び下痢症の感染症流行予測モデルの開発作業が大きく遅延した。結果として、気候予測を基にした流行予測モデルは技術的観点から肺炎には適用が困難であることが明らかになったが、下痢症についてはこの遅延が影響し、終了時評価時点ではようやくモデルの開発作業の検討が開始された段階である。本件は有効性に対する阻害要因と整理できる。

３－５　結論

本プロジェクトでは、JAMSTEC の開発した SINTEX-F2 と CSIR が開発した可変解像度地球システムモデルによる地球規模気候予測システムの精度の向上を図り、かつ予測のダウンスケーリングにも成功した。これにより、特に南部アフリカ地域の気候を高解像度で予測することを可能にした。また、プロジェクトは、改善された気候予測モデルを活用することで、特にマラリアについて 3 つの流行予測モデルの開発に成功した。これら 3 つのモデルはそれぞれ異なる特徴を有し、シーズンごとのマラリア・アウトブレイクを、異なる時間スケールと予測基準、相互情報交換性を伴って、高精度で流行予測を行い、事前の対策の準備を可能にするレベルに達している。プロジェクトは、実際に 2017/2018 年シーズンのマラリアのアウトブレイク予測を提供し、その情報に基づき時宜を得た対策を行うことができた。

しかしながら、介入効果を明らかにするためには、その科学的エビデンスを明らかにすることが必要である。今後は、南アフリカ側が中心となって設立される iDEWS 事務局によって、エビデンスの構築やそれに基づく運用指針の最適化（予測情報に基づく予防対策の実施含む）の実施が期待される。加えて、iDEWS 事務局は、本プロジェクトの成果を南アフリカ国内の高浸淫地域だけでなく、マラリアの流行する近隣国へも展開することが期待されている。さらには、予測モデルの更なる改善を行いながら気候予測モデルの他地域及び他分野への適用、例えば農業や防災分野などへの応用も期待される。このように、気候予測情報が他分野に適用されれば、プロジェクトの成果が大きな正のインパクトを創出する可能性が期待できる。

他方、本プロジェクトの下、協同研究を通して双方の研究機関の能力強化も図られ、これまでに共同研究成果が数多く国際誌に発表されている。プロジェクト終了後も、特に気候予測に基づくマラリア流行予測モデルの更新や気候予測情報に基づく対策の効果などにかかわる研究成果が継続して創出され、関連する学術論文も今後更に数多く発表されることが見込まれる。

以上の結果から、プロジェクトへの効果的な人材投入や想定外の活動遅延などにより「効率性」は中程度であったが、「妥当性」「有効性」「持続性」は高いと評価された。また、終了時評価時点でも本プロジェクトの研究成果の社会実装が具体的に見込まれることから、将来的な正のインパクトも大いに期待できる。これらを総合すると、学術的にも ODA 技術協力としても本プロジェクトの達成度は非常に高いと評価できる。

３－６　提言（当該プロジェクトに関する具体的な措置、提案、助言）

（1）iDEWS 事務局の設立と発展

南アフリカ側関係機関は、2018 年 12 月に設立宣言された iDEWS 事務局の役割と機能の明確化を図り、プロジェクト期間が終了する 2019 年 5 月までに実際の活動を開始していること。

（2）マラリア流行予測情報に基づいたマラリア予防対策の有効性の実証

プロジェクト期間終了後もマラリア流行予測情報に基づいた予防・診断・治療面における介入効果のエビデンスを構築すること。エビデンスに基づいたマラリア対策の運用指針の最適化を図ること、及び得られたエビデンスや経験をグローバルなアクティビティへと昇華させるために WHO 等への情報提供を行うことを期待する。

（3）周辺国への経験の共有

iDEWS 事務局が、プロジェクトで開発された成果をリンポポ州と国境を接するモザンビークをはじめ“Elimination 8”メンバー国に共有する体制を整えていくこと。また、iDEWS 事務局は日本側研究機関との協力体制を長期的に継続していくことを期待する。

（4）下痢症研究の実用化

プロジェクト関係者は iDEWS 事務局と協力し、気候予測に基づく下痢症の有病率及び発生件数の変動モデルを開発するために、更に研究を継続する必要がある。なお、下痢症の予測モデルを構築する際、将来利用可能となれば、実験室サーベイランスシステムからの病原体データの活用も検討すべきである。

３－７　教訓（当該プロジェクトから導き出された他の類似プロジェクトの発掘・形成、実施、運営管理に参考となる事柄）

SATREPS プロジェクトにおける研究成果の想定されるユーザー機関（国レベル、地方レベル）の戦略的巻き込み

本プロジェクトは SATREPS の下、技術協力プロジェクトの枠組みで実施される国際共同研究であり、その結果として、南アフリカと日本の研究機関が分野横断的協同研究により気候予測に基づく感染症予測モデルを開発した。また、プロジェクトは予測情報に基づく感染症予防対策にかかわるエビデンスの構築や実現可能性の高い運用指針の策定を行い、将来的には設立予定の iDEWS 事務局の下で公的サービスとして国内外の浸淫地域への適用をめざしている。

その実現のためには、予測情報の実際のユーザー機関である州レベル行政機関（LDOH）だけではなく、国レベルの感染症分野の政策・戦略策定を担う NICD、気象・気候にかかわるサービスや研究開発を担う国家機関である SAWS の協力が必要である。プロジェクトは NICD 及び SAWS をプロジェクトの前半でメンバーに迎え入れ、SATREPS の事業目的である「研究成果の社会実装」を念頭にこれらの政策・戦略策定機関、研究成果のユーザー機関と協力の下でプロジェクトを進めてきた。これにより、終了時評価時点で南アフリカ側実施機関が中心となって iDEWS 事務局の設立が計画され、予測情報に基づく感染症予防対策の実現に向けた他分野連携アプローチが継続する見込みである。このことはプロジェクトの「持続性」や「インパ

クト」を大きく高めたと認められた。

　このように、プロジェクトは「研究成果の社会実装」に向けた実施体制の構築に早い段階から取り組み、研究機関間の分野横断的アプローチだけではなく、実際のユーザー機関、政策・戦略策定機関となるさまざまなレベルの行政機関も実施体制に組み入れることで、持続性やインパクトを大いに高めた。したがって、他の SATREPS の下で実施される技術協力プロジェクトにおいても、実施体制の構築には単に研究機関や監督省庁だけではなく、実際のユーザー機関や政策・戦略策定機関を含めることが効果的である。ただし、このような他分野連携の下で実施体制を構築した場合、国際連携に加えて先方機関の連携調整が困難となる可能性があることから、国内・国際的な連絡調整方法などを含むプロジェクト運営管理を適切に実施するための準備・取り組みが必要である。

３－８　フォローアップ状況

　特になし。

Evaluation Summary

<table>
<tr><td colspan="3">1. Outline of the Project</td></tr>
<tr><td colspan="2">Country: the Republic of South Africa</td><td>Project Title: the Project for Establishment of an Early-Warning System for Infectious Diseases in Southern Africa incorporating Climate Predictions</td></tr>
<tr><td colspan="2">Issue/Sector: Healthcare and medical treatment</td><td>Cooperation Scheme: Technical Cooperation Project (Science and Technology Research Partnership for Sustainable Development: SATREPS)</td></tr>
<tr><td colspan="2">Division in charge: Health Team 2, Health Group 1, Human Development Department</td><td>Total Cost： Approx. 250 million JPY</td></tr>
<tr><td rowspan="3">Period of Cooperation</td><td rowspan="3">(R/D):
12/May/2014 – 11/May/2019</td><td><u>Partner Country’s Implementing Organization:</u> the Department of Science and Technology (DST); the National Department of Health (NDOH); the Applied Centre for Climate and Earth Systems Science (ACCESS); the South African Medical Research Council (SAMRC); the Council for Scientific and Industrial Research (CSIR); the National Institute for Communicable Diseases (NICD); the South African Weather Service (SAWS); the Department of Health-Limpopo (DOHL); the Department of Health-Limpopo, Malaria Control (DOHL-Malaria); the University of Cape Town (UCT); the University of Limpopo (UL); the University of Pretoria (UP); the University of Venda (UV); and the University of the Western Cape (UWC)</td></tr>
<tr><td><u>Supporting Organization in Japan:</u> the Nagasaki University Institute of Tropical Medicine; and the Japan Agency for Marine-Earth Science and Technology (JAMSTEC)</td></tr>
<tr><td>Other Related Projects: None in particular</td></tr>
<tr><td colspan="3">1-1 Background of the Project
It is suggested that the epidemic of certain infectious diseases such as malaria, diarrhea and pneumonia can be affected by climate variability, in particular, air-sea interactions such as La Niña effect, seasonal variability of ambient temperature and precipitation. Southern African countries including the Republic of South Africa (hereinafter referred to as “South Africa”) are being subject to danger of the said infectious diseases. In particular, diarrhoea and pneumonia were the top two causes of deaths of children younger than 5 years of age (21.4% and 16.2% respectively in 2007)[1] in South Africa at the time of project designing (in 2013). Malaria is well controlled in comparison to other Southern African countries. However, the Northeast regions of South Africa sharing the borders with malaria endemic countries such as Mozambique and Zimbabwe including the Limpopo province, which is the target region of the Project, are especially exposed to malaria infection risks[2]. Actually, more than 10,000 malaria incidences were reported in South Africa in 2014 when the Project was commenced. As was just described, the relationship between climate variability and the incidence</td></tr>
</table>

[1] UNDER-5 MORTALITY STATISTICS IN SOUTH AFRICA: Shedding some light on the trend and causes 1997-2007; April 2012, the Burden of Disease Research Unit, the South African Medical Research Council

[2] World Malaria Report 2015, WHO

of infectious diseases is strongly suggested; nevertheless, its concrete correlative relationship has not been scientifically proven. For this reason, climate-based infectious disease epidemic prediction has not been used for practical measures for infectious diseases control to this date.
On the other hand, a climate variability prediction system with high prediction accuracy (SINTEX-F) was developed through the collaborative research of the South African and Japanese research institutes with the support of a former JICA's technical cooperation entitled "*the Project for Prediction of Climate Variations and its Application in the Southern African Region*" (2010–2013), which was implemented under the scheme of the Science and Technology Research Partnership for Sustainable Development (hereinafter referred to as "*SATREPS*"). On the basis of the said project, "*the Project for Establishment of an Early-Warning System for Infectious Diseases in Southern Africa incorporating Climate Predictions*" (hereinafter referred to as "*the Project"*) is launched in May 2014 under the scheme of SATREPS, aiming to further improve the prediction skill of the existing seasonal climate forecasting system, followed by the establishment and subsequent operability verification of climate forecast-based infectious disease early-warning systems (hereinafter referred to as "*iDEWS*"), especially for malaria, diarrheal diseases and pneumonia.

1-2 Project Overview

(1) Project Purpose

A climate-based early-warning system model for infectious diseases control is established as a precursor for further application across southern Africa.

(2) Outputs

1) Climate-based infectious disease epidemic prediction models are developed especially for malaria, pneumonia and diarrhoea.
2) Operational guidelines of iDEWS are developed in the Limpopo Province.
3) Prediction performance and operability of the iDEWS are verified.

(3) Inputs

The Japanese side:

– **Dispatch of JICA experts:** a total of 3 Long-term Experts (1 for Epidemiology/medical entomology research and a total of 2 Project Coordinators), a total of 101 M/M (Man/Month) / Short-term Experts: a total of 16 Experts, 71.7 M/M
– **Counterpart Researchers' visit to Japan:** A total of 35 counterpart personnel for sharing the research progress and outcomes, discussing on the research plan of operation, participating in symposia and so on. (a total of 347 days);
– **Training in Japan:** A total of 7 counterpart personnel for the training of statistical analyses, data management, etc. in the research of climatology and/or infectious disease control;
– **Provision of Equipment:** Automatic Weather Observation System, research / laboratory instrument and related equipment such as microscopies, artificial environment test system, personal computers for data processing and analyses, software for data analyses, etc.; and
– Overseas Activities Costs: Travel cost, Consumables for research activities, Communication cost, etc.

The South Africa side:

- **Allocation of Counterpart Personnel:** A total of 57 counterparts such as Project Director, Project Manager, researchers, administrative and technical officers;
- **Facilities, Equipment and Materials:** Facilities, Equipment and Materials: Project office spaces in CSIR and DOHL-Malaria; Laboratory space un DOHL-Malaria; Existing research instruments, equipment and/or devices in the South African counterpart organizations; Available data, information and/or specimens related to the Project; and Availability of teleconference system in CSIR;
- **Local Costs:** A total of ZAR 5,700,000 (approx. 419,000 USD) for field survey in the Limpopo province, the development of database for hospital inpatients information, domestic transportation of the South African counterpart personnel, utilities for the project office, consumables used for the project activities, custom clearance of the materials procured in Japan such as research instruments and reagents, etc.

2. **Final Evaluation Team**

Members	Dr. Kaname KANAI	Leader	Executive Technical Advisor to the Director General, Human Development Department, JICA
	Ms. KAWAGUCHI Misaki	Cooperation Planning	Assistant Director, Health Team 2, Health Group 1, Human Development Department, JICA
	Dr. Yoichi INOUE	Evaluation Analysis	Senior Consultant, Consulting Division, Japan Development Service Co., Ltd.
	Prof. Dr. WATANABE Haruo (Observing member)	Infectious Diseases Control Research	Program Supervisor, International Collaborative Research Program, Department of International Affairs, AMED Professor, the Graduate School of the International University of Health and Welfare
	Mr. Katsumi ISHII (Observing member)	Planning and Evaluation	Deputy Manager, Division of International Collaboration, Department of International Affairs, AMED (Observing member)
Period of Evaluation	7/Jan/2019 – 23/Jan/2019		Study Type: Final Evaluation[3]

3. **Summary of Evaluation Results**

3-1 Achievements

（1）Output 1: Achieved in general.

JAMSTEC, with the support of the CSIR, had succeeded in developing a novel seasonal prediction system based on an ocean-atmosphere coupled general circulation model called SINTEX-F2 with higher resolution. The SINTEX-F2 improved its prediction accuracy in southern Africa significantly. Moreover, The JAMSTEC had succeeded in downscaling of global seasonal forecasting into local-scale prediction covering as narrow as approx. 10km2. Meanwhile, the UP had succeeded in developing an individualistic ensemble climate forecast model and subsequent downscaling. These climate forecasting and downscaling technologies are combined with infectious disease epidemic prediction models as described below.

[3] The expression of the "Terminal Evaluation" is used in the "JICA Guidelines for Project Evaluation" (2nd edition) officially; however, an expression of "Final Evaluation" is used in this evaluation report in accordance of a recommendation from the JICA South Africa Office in consideration of local protocol.

Concerning malaria, the Project has developed two epidemic prediction models on the basis of the non-linear statistical model and the machine-learning-based model, and both of which have demonstrated sufficient prediction performance enough to apply the prediction results to practical malaria prevention and control measures. Those models have succeeded in predicting relatively large malaria epidemic for the first time in 20 years in the 2016/2017 season retrospectively; subsequently, have also succeeded in predicting the magnitude of malaria epidemic in the 2017/2018 season, same as that in the previous season, prospectively. The UP also has developed a statistical malaria epidemic prediction model, based on an ensemble climate forecast, with sufficient prediction performance for practical use, i.e., the correlation coefficient between the predicted value and the practically-observed values are 0.7 or higher. Each model has each characteristics of prediction performances such as prediction lead-time and prediction duration; thus, it is anticipated that the planning of countermeasures for the prevention and control of malaria epidemic can be done in an effective and efficient manner by providing prediction information by combining these different models in consideration of its characteristics.

Thus, as for malaria, two epidemic prediction models based on climate forecasting demonstrated sufficient epidemic prediction performance enough to apply them to practical prevention and control measures. The prospect of developing models for diarrhoea is also obtained; to be more specific, the development work can be completed within 2 to 3 years' time since the development work will be surely continued under the iDEWS Bureau. Though it became clear that the model development was technically difficult on pneumonia, it can be said that important experience and knowledge were given for the future research activity. Further, the Project had published as much as 44 research articles in peer-reviewed international journals as of the time of the Terminal Evaluation. For these reasons, the Output 1 seemed to have generally achieved its objective from the viewpoint of the collaborative research cooperation.

(2) Output 2: Achieved in general.

Concerning the standards for disseminating forecast information, it was initially assumed to implement outbreak prevention through the issuance of alert information based on the early detection of a malaria outbreak and early containment response measures. However, when considering the characteristics of the malaria epidemic prediction models and its operation in the Limpopo province, where the number of malaria cases is rather small, compared with malaria high invasive countries such as Mozambique, the parties concerned agree not to issue individual outbreak alert information but to regularly announce epidemic prediction information and to take actions in accordance with operational guidelines, etc. The Project has succeeded in developing two malaria epidemic prediction models based on the non-linear statistical model and the machine-learning-based model, and is being examining the method for constructing malaria epidemic forecast information in consideration of its characteristics of prediction performance.

In addition, the preparatory committee for iDEWS operation, which was launched in January 2017, is not limited to research institutions, but involves national-level organisations such as NDOH, the SAWS and the NICD, which are key for future institutionalization, as well as the LDOH which are regarded as an actual user of prediction information on infectious disease epidemics. Under this preparatory committee, operational investigations were made, including validation of the predictive performance of malaria epidemics in the Limpopo province and the response (intervention) based on prediction results in advance of the 2017/2018 malaria epidemic season (during the 4th quarter in

2017). As a result, all member organisations evaluated the predictive performance of climate forecast-based epidemic prediction models as practical levels, leading to consensus among the relevant organisations towards the establishment of the iDEWS Bureau. Since the abovementioned pilot study confirmed the need for further experience in order to develop operational guidelines, its developing work cannot be completed within the project period; nevertheless, the verification of ideal operation is likely to be carried out steadily under the iDEWS Bureau.
In conclusion, the objectives of the Output 2 are considered to have been met, as well as well-experienced and evidence-based iDEWS operation guidelines are expected to be completed steadily within the first few years after the completion of the project period.

(3) Output 3: Achieved in general.
As mentioned above, the Project confirmed that the epidemic prediction models could predict the number of malaria cases in the 2016/2017 epidemic season when a large epidemic occurred for the first time in 20 years with high accuracy; based on this result, the prediction information from the models was practically applied to malaria prevention and control measures in the Limpopo province in the following season of 2017/2018. The results showed that the intervention may have affected the reduction of malaria mortality as well as slight decrease in the number of reported cases. However, it is considered that further detailed analyses should be needed for verifying the effect of prediction information based preventive measures (interventions) by taking various alternative factors such as the migration of malaria carriers from neighbouring countries and so on into consideration.
The correlation between the epidemic and climatic variables and climatic events was also confirmed for diarrhoea, and at the time of the Final Evaluation, the Project has just commenced the examination and discussions for the development of prediction models practically. Therefore, it is not possible to assess the predictive performance and operability in diarrhoea control within the project period, but it is likely that the developing work will be continued under the iDEWS Bureau once the model is developed.
In conclusion, the model's predictive performance and operability are expected to be verified under the iDEWS Bureau and the development work of iDEWS is steadily completed within a few years after the end of the project period; thus, it is deemed that the objectives of the Output 3 are generally considered to have been met.

(4) Project Purpose: Achieved in general.
Efforts made by both Japanese and South African research institutes and administrative bodies have improved the accuracy of the seasonal climate prediction systems in the southern African region and led to successful downscaling. Based on this result, the Project has developed three malaria epidemic prediction models with practical-level prediction performance, and actual preventive measures based on prediction information are piloted, and the effects and problems (e.g., the necessity of developing the operational guidelines for the implementation of prevention and control measures against malaria epidemics and subsequent its optimization in consideration of available human and financial resources, packaging those elements of iDEWS practical operation in light of dissemination to neighbouring countries in future, etc.) are confirmed. South African research institutes and administrative agencies highly appreciated project’s achievements and have agreed the intention to establish the iDEWS Bureau to make a climate-forecast-based infectious disease epidemic prediction service, especially for malaria, as a part of administrative services in future. In addition, the climatological and

infectious disease research groups of the project's research institutes have started the joint research with the Mozambican authorities concerned as of the time of the Final Evaluation, and the prediction performance of the models will further be improved hereafter. In addition, the cooperation with the "*Southern African Elimination 8 Initiative*", which was established under the Southern African Development Community for the elimination of malaria with a consorted effort by eight southern African counties, is becoming concrete on the malaria, and the expansion to the southern African region is also greatly expected. Although the modelling of diarrhoea has not been achieved due to the delay in the first half of the project period, the development work is supposed to continue under the iDEWS Bureau. Although it has been confirmed that it is technically difficult to develop epidemic prediction models based on climate variation prediction for pneumonia, the process to judge it may have provided an important basis for consideration of its application to other diseases.

Thus, the establishment of an early warning system model based on climate forecasting for controlling infectious diseases as the first step towards its application to southern Africa countries (the Project Purpose) is likely to be steadily achievable within a few years. As mentioned above, significant achievements were confirmed both from the academic perspective and from the perspective of ODA technical cooperation. Besides, the current-observable issues have been appropriately organized. For these reasons, it is deemed that the Project can be regarded as largely achieving its objectives as of the time of the Final Evaluation.

3-2 Summary of Evaluation Results

（1）Relevance

The relevance of the Project has been highly maintained hitherto.

In Southern African countries including South Africa, infectious diseases are major threats. Though under-5 mortality of diarrhoea and pneumonia are being reduced in recent years, those two diseases are still being regarded as major under-5 causes of death in South Africa (8.7% and 16.9%, respectively in 2015) in South Africa.

Malaria is well controlled in comparison to other Southern African countries. However, the Northeast regions of South Africa sharing the borders with malaria endemic countries such as Mozambique and Zimbabwe including the Limpopo province, which is the target region of the Project, are especially exposed to malaria infection risks. Actually, the number of reported malaria cases was thought to be at a level close to elimination with 4,323 cases and 34 deaths in 2016, while in 2017, a large malaria epidemic had occurred; in particular, the number of reported cases and deaths were 22,517 (more than 5 times higher than that in the previous year) and 264 (approximately 5 times higher), respectively. The following year of 2018 saw a similar magnitude of the epidemic; therefore, it is obvious that South Africa is still at risk for malaria. Under such conditions, the national DOH of South Africa positioned the reinforcement of infectious disease countermeasures as the "*Primary Medical Service*" of the national program in the "*Strategic Plan 2015-2020*". It promotes the strengthening of the infectious disease surveillance system, strengthening preparedness and core response capacities for public health emergencies in line with the International Health Regulations and promoting the development of science and technology.

Meanwhile, in the ODA policy in Japan also, infectious disease countermeasures are stressed and the "*Yokohama Action Plan 2013-2017*" that is the basis of the specific policy of the "*Yokohama Declaration 2013*" that was agreed in the 5th Tokyo International Conference on African Development (TICAD V) in June 2013 reviewed the importance of infectious diseases countermeasures and also indicates the importance of the approach towards climate change issues by many sectors. The "*Nairobi Declaration*" that was adopted in TICAD VI that was implemented in August 2016 confirmed that the "*Yokohama Declaration*" and "*Yokohama Action Plan*" are effective until the next TICAD in 2019.Further, WHO clarifies the necessity for the countermeasures for the impact of climate change such as global warming on the health of people. In particular, "*WHO Global Programme on Climate Change & Health*"（2016）indicates the importance of obtaining the scientific basis relating to climate change and health. Therefore, the development of infectious disease epidemic prediction models based on the correlation between climate change and malaria, pneumonia, and diarrhoea and scientific analysis relating to the administrative handling based on the prediction information are also considered to meet such international demands.

Furthermore, the Project' achievements is supposed to disseminate the technologies or infectious disease control measures to neighbouring countries as a concept of the Project from the beginning, and it was obvious that only South Africa is capable of doing highly-advanced research with Japanese research institutes. Therefore, the rationale for selecting South Africa as a partner and the target site is considered to be secured.

Based on the above, the consistency of the purpose of the Project that implements infectious disease countermeasures based on the technical enhancement of South African – Japan research institutes with the South African health policies, science and technology policies, and the needs from community residents in South Africa are enhanced further.

（2）Effectiveness

The effectiveness of the Project is considered to be high.

During the project period, a number of scientific papers on climatological research (mainly, that related to the development or improvement of the seasonal climate prediction system and subsequent downscaling) have been published in frontline peer-reviewed international journals as of the time of the Final Evaluation. Although only a few studies have been conducted on models for predicting epidemics of infectious diseases based on climate forecasts in other research groups, three models for predicting epidemics of malaria with different characteristics have been developed and confirmed to be at the practical level. Since the application of prediction information by these models to actual malaria prevention measures will be carried out followed by the verification of intervention effects from the scientific viewpoint, it is anticipated that many related research findings and outcomes are anticipated to be published in international journals even following the completion of the project period. On the other hand, unlike international joint research with other developing countries, the Project has been continuing technological cooperation and exchanges at a very high level as equal partners, challenging frontier sciences such as development of a model for predicting epidemics of infectious diseases based on climate forecasting, and practical application to the prevention and control of malaria epidemics. The Project commenced such a cross-cutting research with no experience and even record; however, gained many research findings and outcomes with high possibility to apply them to the society as of the time of the Final Evaluation. This is thought to have greatly improved the capabilities of relevant organisations such as research institutes in both South Africa and Japan, central and local administrative agencies and even health facilities in South Africa; thus, the Project could have produced significant achievements from the perspective of ODA assistance.

Though the Project could not complete to establish iDEWS for each of three target diseases, the achievement level of the Project from both academic and ODA points of view is significantly high; thus, it is deemed that the "*Effectiveness*" of the Project is high in general.

(3) Efficiency

The efficiency of the Project is moderate for following reasons.

Two (2) long-term JICA experts arrived at their positions in South Africa in October 2014, five (5) months after the commencement of the Project, which resulted in delays in the installation of research instruments as well as the commencement of data collection activities. Aside from this, it took longer-than-expected time for the South African project member organisations to enter into the Memorandum of Understanding (MOU) among them, which resulted in some delay in the acquisition of the terrestrial climate data. Furthermore, the budget allocated by the South African side for the construction of the database of hospital inpatient information became available eventually in 2016, resulted that the modelling work has lagged behind the schedule by 6-12 months; for this reason, the Project could not complete the epidemic prediction modelling for diarrhoea as of the time of the Final Evaluation.

Having said that, the South African and Japanese research institutes have continuously and frequently been communication each other through various channels such as JCC meetings, symposia held both in South Africa and Japan, day-to-day emailing and teleconferences as of the time of the Final Evaluation; for these reason, it is deemed that the management of the progress as well as the generation of research outcomes has generally been appropriate. This can be explained by the significant achievement of research outcomes of the Project as of the time of the Final Evaluation. Further, the causes of the delays are seemed to be external factors, and the South African side had been putting best effort to the Project by allocating their own budget for the project activities as well as working on the orchestrating the iDEWS preparatory committee. Other inputs of the Project such as the Provision of Equipment as well as the Training in Japan were seemed to be done effectively. Therefore, it is considered that the project management itself has been appropriate in general throughout the project period.

(4) Impact

The following positive impacts are confirmed and/or expected by the implementation of the Project.

The climate forecasting models improved by the Project are already capable of forecasting climate in Mozambique, consequently, it is technically possible to perform malaria epidemic prediction using current climate forecast-based epidemic prediction models even now. Moreover, the Project, both the climatology and infectious disease control groups, had already commenced operational and research collaboration with the Mozambican authorities concerned; thus, the benefits derived from the achievements of the Project can be anticipated in Mozambique in future. On the other hand, the Elimination 8 has shown great interest in the application of climate-based malaria epidemic prediction to its member countries, and consultations on specific ways of collaboration have been initiated as of the time of the Final Evaluation. If cooperation with other Southern African countries can be initiated through Elimination 8, it is likely that the said models can be disseminated to those countries by fine-tuning them using malaria epidemic data in each country.

However, in order to realize the application of the iDEWS for malaria to other provinces in South Africa and even other countries, the Project should create individual evidence of the effect of each possible intervention based on the epidemic prediction for the prevention and control of malaria;

subsequently, on the basis of those evidences, the Project is required to realize an optimization of operational guidelines in consideration of available resources such as human resources and budget. Furthermore, the Project should perform a scientific verification on the effect of interventions for the prevention and control of malaria taken in accordance with the optimised operational guidelines on the number of malaria cases and related casualties, and consequently, demonstrate a comprehensive evidence of the effectiveness of the malaria iDEWS. If these are all realized, the dissemination of the malaria iDEWS can be disseminated to other regions in South Africa and even neighbouring countries eventually.

On top of that, several positive impacts of the Project have been observed or expected as follows: 1) Discovery of the relationship between the decadal change in the precipitation in southern Africa and the malaria incidence[4]; 2) Functional enhancement of the Tzaneen Malaria Institute; and 3) Collaboration amongst crosscutting stakeholders on the development of iDEWS as a platform.

（5）Sustainability

A self-sustainability as well as a self-deployment of the benefits provided by the Project can be expected to some extent.

Political and Institutional Aspects: the political importance of the implementation of the infectious disease countermeasures based on the results of the relevant research (based on the reason) while enhancing the technological capability of the development of climate change prediction models and infectious disease prediction models in South Africa is expected to be strongly maintained up to and also beyond the end of the Project. Meanwhile, the relevant organisations of the South African side highly evaluated the climate forecasting-based malaria epidemic prediction models as achieving the sufficient level for the practical application of the forecast information to the prevention and control of malaria, and took practical actions to establish the iDEWS Bureau as of the time of the Final Evaluation. For the meantime, it is anticipated that the iDEWS bureau will work on the optimisation of the operational guidelines within two years following the completion of the Project, and evidence on the effects of iDEWS on malaria prevention measures will be created. By presenting the evidences that has been developed to the relevant authorities concerned, the member organisations is aiming to position the iDEWS Bureau as part of the national administrative body. The political sustainability of the Project is expected to some extent at the time of the Final Evaluation.

Financial Aspect: the research institutes in both South Africa and Japan have a high research capacity, and it is considered that the Project is leading the world with regard to the research on the development of climate forecast-based infectious disease epidemic prediction model with sufficient prediction performance for practical application to epidemic control measures and subsequent interventions based on prediction information. For these reasons, each research institute is considered to have a high capability of research enough to acquire external competitive research funds toward this research topic. On the other hand, as mentioned above, given that the iDEWS is included as a part of the infectious disease control system in South Africa, the budget for the continuous operation is expected to be secured as an Administrative system. Since future adaptation of the iDEWS in other provinces and neighbouring countries of South Africa is considered, it is desired that a consorted effort by the member organisation of the iDEWS Bureau should continuously be done for packaging the epidemic prediction models, operational guideline, cost analyses for introducing and running the

[4] As a consequence of the development of the SINTEX-F2, the Project found the decadal change in precipitation in the South African region and that decadal change also correlated with the number of malaria incidences in that area.

iDEWS.

Technical Aspect: the research capacity of both South African and Japanese research institutes is high, and it is strongly expected that novel research capabilities acquired through the Project will be improved even after the end of the project period. Besides, both NEKKEN and JAMSTED have demonstrated a willingness to continue joint research and related technical cooperation with the South African project member organisations following the termination of the Project, and also are supposed to participate or technically-support the operation of the iDEWS Bureau by any means. Meanwhile, the Project has succeeded in developing three (3) climate forecast-based malaria epidemic prediction models with sufficient prediction performance for practical use; in particular, the machine-learning-bases model by JAMSTEC, the non-linear statistical model by NEKKEN and the linear statistical model by the UP). In parallel, JAMSTEC and the UWC have been working on the development of mathematical model-based malaria epidemic prediction models individually on the basis of the VECTRI model and the compartmental model, respectively. Though those two mathematical models have not reached a sufficient level for practical application to countermeasures at this point, both JAMSTEC and the UWC are anticipated to continue the development work even following the completion of the Project, since mathematical model-based infectious disease epidemic prediction models have a potential to demonstrate high applicability to other regions. Having said that, though the verification of intervention effects of prediction information-based malaria epidemic prevention and control measures as well as the optimisation of its operational guidelines based on the verification results are supposed to be continued at the initiative of the iDEWS Bureau, it is suggested that the Project should seek a technical support from some persons with public health research and/or professional practice to do such activities.

3-3 Factors that promoted the attainment of the Project

(1) Concerning the project design

None in particular.

(2) Concerning the implementation process of the Project

Many institutes including the implementation institutes participated in the Project. Frequent communications and discussions were held via e-mail and telephone within both the research groups that are engaged in the development of climate change prediction models and the groups that are engaged in the development of infectious disease epidemic prediction models. These are the factors for achieving smooth implementation of joint research in remote mode between South Africa and Japan and for acquiring the research results as described above. In addition, the Project strategically included two national organisations, which leads to the reinforcement of the project implementation system for the practical application of project’s achievements. It is considered that these enhanced the effectiveness of the Project.

3-4 Factors that impeded the attainment of the Project

(1) Concerning the project design

At the time of the Mid-term Review, the Joint Review Team provided a recommendation to allocate a JICA expert with related expertise in order to conduct the prevention and control of malaria epidemics on the basis of the evidences in an effective and efficient manner; however, it was not realized. As a result, this might cause that ad hoc countermeasures with less evidences or discussions were taken for preventing epidemic of malaria in 2017/2018 season when a large-scale outbreak of malaria is predicted.

Though many factors might affect the unsuccess of effective allocation of a JICA expert based on the recommendation, it can be considered that this unsuccess hindered from maximizing activity results by effective allocation of necessary human resources. Therefore, this can be regarded as a hindering factor against the "*Efficiency*" of the Project.

（2）Concerning the implementation process of the Project

It was agreed that the computerization of paper-based inpatient hospital information followed by the construction of database would be done by the input from the South African side. The said works require a lot of labour force; thus, it was required for the South African side to allocate some budget to outsource. Unfortunately, the budget took longer-than-expected time to become available of the budget on the South African side. This caused a certain delay in the project activities especially for the development of infectious disease epidemic prediction modelling for pneumonia and diarrhoea. The Project found, eventually, that pneumonia is technically inapplicable for the development of a climate forecast-based epidemic prediction model; however, the said delay has affected for the Project to develop a model for diarrhoea; consequently, the Project had just commenced the development work for it at the time of the Final Evaluation. For this reason, this can be recognized as a hindering factor to the effectiveness of the Project.

3-5 Conclusions

The Project has achieved the improvement of the climate prediction skill on the JAMSTEC SINTEX-F2 and the CSIR Variable Resolution Earth Systems Model (VrESM) and the development of downscaling techniques, especially in the Southern African Region. By utilising the improved climate prediction products, the Project also successfully developed three (3) climate-based epidemic prediction models for malaria. These three (3) models, which have different characteristics, can predict the likelihood of epidemic per season, at different, interoperable, time scales, within target range of accuracy, and the potential extent of said epidemic in once instance. The Project provided a prediction of malaria outbreak in the 2017/2018 season, which led to timeous intervention for malaria control. However, it is necessary to make further scientific evidence to clarify the effectiveness of the intervention. On the initiative of South Africa, the iDEWS Bureau is expected to produce evidence for the optimization of operational guidelines (including countermeasures required based on predictions of outbreaks) after the Project's completion. The iDEWS Bureau is expected to disseminate the prediction results, affected areas in South Africa and even in neighbouring countries. In addition, the iDEWS Bureau is expected to further develop the prediction models, and to explore expanding the application to other regions and other fields such as agriculture, disaster preparedness, etc. in future. The Project's outcome has the potential to make a significant impact if climate forecasting information can be applied to other sectors.

Many academic papers have been published in international journals through collaborative research work under the auspices of the Project with mutual capacity development. Even after the Project's completion, it is expected that research outcomes will continue to be created as a result of the update of the malaria epidemic prediction model based on the climate forecast and the effect of measures based on the forecast information, with a number of research papers expected to be published.

In terms of the evaluation results of the Project, the "*Relevance*", the "*Effectiveness*", and the

"*Sustainability*" of the Project are all high, although "*Efficiency*" is moderate due to the delay of the data collection activity and the dispatch of an expert. On the other hand, there are positive "*Impacts*" which will be expected in future practical application of the research findings and outcomes to society, at the time of the Final Evaluation. Therefore, it is considered that the Project's achievement is very high, both academically and as technical cooperation.

3-6 Recommendations

(1) Establishment and Development of iDEWS Bureau

The proposed iDEWS Bureau should clarify its roles and functions and commence the actual operations by May 2019 when the Project officially ends.

(2) Verification of the effectiveness of the predication information-based interventions for the prevention and control of malaria epidemics

The iDEWS Bureau is required to verify the effectiveness of the intervention from the aspects of prevention, diagnosis and treatment of malaria, which had been taken based on the malaria epidemic prediction information, even after the end of the project period. The iDEWS Bureau is also expected to optimize the operational guidelines for measures against malaria epidemics based on the evidences and to provide information to WHO etc. to sublimate the evidences and experiences to global activities.

(3) Dissemination of the experience to the neighbouring countries

The iDEWS Bureau should take initiative for the dissemination of the Project's experience and outcomes not only to Mozambique, which shares the border with the Limpopo province, but also the member countries of the Elimination 8. The iDEWS Bureau and Japanese research institutes are expected to maintain their continuous cooperation and joint research on a long-term basis.

(4) Operationalisation of diarrhoeal disease research

The project partners, in collaboration with the iDEWS Bureau, should pursue research on the diarrhoea disease toward further development of climate-based models for the prediction of diarrhoea disease prevalence and incidence variability. The work should consider the utilisation of pathogen data from the laboratory-based surveillance system when available in future.

3-7 Lessons Learnt

Strategic involvement of envisaged user organisations of research findings and outcomes at both local and national levels

The Project is an international collaborative research implemented in a framework of JICA's technical cooperation under the scheme of SATREPS; consequently, developed climate forecast-based infectious disease epidemic prediction models through the international and crosscutting collaborative research between South Africa and Japan. The Project is aiming to create evidences of the effectiveness of climate forecast-based countermeasures for the prevention and control of infectious disease epidemics and subsequent development of optimal and feasible operational guidelines, followed by its application to both domestic and international affected areas as one of public services under the iDEWS Bureau. In order to realize that, it was necessary for the Project to gain supports not only from the provincial administration body as a direct user organisation of the epidemic prediction information (i.e., LDOH) but also from the NICD of the national policy and strategy-making bodies for infectious disease control as well as the SAWS of the national agency bearing weather and climate-related services, research and development. For this reason, the Project had incorporated them into the member organizations in the initial phase of the project period, and advanced the project activities with the support of both local users and national policy-makers in consideration of the practical application of research findings and outcomes to the society, which is an objective of SATREPS. Consequently, the establishment of the iDEWS Bureau is planned at the initiative of the South African side at the time of the Final Evaluation; therefore, it is anticipated that the said multidisciplinary approach for realising the epidemic prediction-based countermeasures for the prevention and control of infectious disease sustains hereafter. This is deemed to enhance the "*Sustainability*" and the "*Impact*" of the Project significantly.

As was described above, the Project has commenced efforts for the establishment of an implementation system for "*the practical application of the research findings and outcomes*" in the early stage of the project period, and enhanced the "*Sustainability*" and the "*Impact*" by taking the crosscutting collaboration amongst research institutes and by incorporating local and national, practical users and policy/strategy-making bodies into the project implementing system. Thus, in other JICA's technical cooperation implemented under the scheme of SATREPS, it can be effective to construct a project implementation system not just by counterpart research institutes and its supervisory agencies but also envisaged user organisations as well as related policy/strategy-making bodies at national level. In this regard, however, such multidisciplinary approach can cause am extra efforts for liaison and coordination both domestically and internationally. Therefore, the preparation and operational management should carefully be done, especially for domestic and international liaison and coordination amongst the multidisciplinary project implementing agencies.

3-8 State of the follow-up

None in particular.

第１章　終了時評価の概要

１－１　調査団派遣の経緯

マラリアや下痢症、肺炎などの感染性疾患は、気候の変動、具体的にはラニーニャ現象などの大気海洋相互作用や気温・降雨量などの季節変動の影響を受ける可能性があることが示唆されている[1]。南アフリカ共和国（以下、「南アフリカ」と記す）を含む南部アフリカ地域ではこのような感染性疾患の危険に常にさらされている。具体的には、プロジェクト計画当時の最新のデータでは下痢症及び肺炎は南アフリカにおける 5 歳未満児死亡の上位 2 原因（それぞれ、21.4%、16.2% : 2007 年）である[2]。マラリアについては他の南部アフリカ諸国と比べるとよく制御されているが､モザンビークやジンバブエなどのマラリア浸淫国に国境を接している南アフリカ北東部、特に本プロジェクトの対象地域であるリンポポ州は依然としてマラリア感染リスクにさらされている[3]。実際に、プロジェクトが開始された 2014 年には南アフリカ全体として 1 万例以上の感染者が発生している。しかし、気候変動と感染性疾患の発生との関係が強く示唆されていながら、その具体的な相関関係が科学的に証明されることがなかったため、気候に基づく感染症流行予測を用いた対策は今日まで実現していない。

他方、地球規模課題対応国際科学技術協力（Science and Technology Research Partnership for Sustainable Development : SATREPS）の枠組みで実施された JICA 技術協力「気候変動予測とアフリカ南部における応用プロジェクト」（2010-2013）は、南アフリカと日本の研究機関の共同研究により、精度の高い気候変動予測システム（SINTEX-F）を開発した。「南部アフリカにおける気候予測モデルをもとにした感染症流行の早期警戒システムの構築プロジェクト」（以下、「本プロジェクト」と記す）は、先のプロジェクトで開発した気候変動予測システムの予測性能を更に高めるとともに、特にマラリア、下痢性疾患及び肺炎について気候予測に基づいた感染症早期警戒システム（infectious Diseases Early Warning System : iDEWS）の構築と運用性の検証を目的とし、SATREPS の枠組みで 2014 年 5 月に開始された。

今回実施する終了時評価調査では、国際共同研究全体の進捗や研究成果の創出状況を確認するとともに、政府開発援助（Official Development Assistance : ODA）事業として相手国における人材育成、能力強化及び開発課題に対する貢献の観点からプロジェクトを評価した。また、評価結果に基づき、支援期間内に着実にプロジェクト目標を達成することや、プロジェクトの達成事項の持続性を強化するための提言を行うことを目的として実施された。

１－２　終了時評価の目的

終了時評価の目的は、以下に示すとおりである。

（1）PDM（version 2）（別添 1）に基づいて進捗をレビューし、評価 5 項目（「妥当性」「有効性」「効率性」「インパクト」及び「持続性」）の評価基準に従って協力期間全体でのプロジェクトの達成度を評価する。

（2）プロジェクトの成果及び目標に対する促進要因及び阻害要因を検討する。

（3）上記の分析結果に基づいて南アフリカ側と共同で残りのプロジェクト期間での活動方針に

[1] A.J. McMichael, et al. Climate change and human health - risks and responses (2003)

[2] UNDER-5 MORTALITY STATISTICS IN SOUTH AFRICA:Shedding some light on the trend and causes 1997-2007; *April 2012*, the Burden of Disease Research Unit, the South African Medical Research Council

[3] World Malaria Report 2015, WHO

ついて協議する。

(4) 今後のプロジェクト目標及び将来の研究成果の社会実装の達成に向けた提言を行うとともに、必要に応じてプロジェクト・デザイン・マトリックス（Project Design Matrix：PDM）の見直しを行う。

(5) 終了時評価報告書に調査結果を取りまとめる。

１－３　終了時評価調査団のメンバー

終了時評価は、JICA 側 3 名の評価メンバーが南アフリカ側関係機関と協議しながら実施した。終了時評価調査団の構成は以下のとおりである。

なお、南アフリカにおける現地調査には、SATREPS の枠組みのなかで日本国内での研究を支援している国立研究開発法人日本医療研究開発機構（以下、「AMED」と記す）[4]は JICA の実施する終了時評価調査と同時に 2 名の調査団を南アフリカにおける現地調査に派遣し、独自の評価調査を行うとともに、専門的見地から研究活動に対する技術的な助言を行った。

＜JICA 終了時評価団員＞

担当分野	氏　名	所　属	現地派遣期間
団長・総括	金井　要	JICA 人間開発部 技術審議役	2019 年 1 月 12 日～ 2019 年 1 月 23 日
協力企画	川口　美咲	JICA 人間開発部 保健第一グループ 保健第二チーム 調査役	2019 年 1 月 12 日～ 2019 年 1 月 23 日
評価分析	井上　洋一	株式会社　日本開発サービス　調査部 主任研究員	2019 年 1 月 7 日～ 2019 年 1 月 23 日

＜AMED 団員＞

担当分野	氏　名	所　属	現地派遣期間
感染症対策研究	渡邉　治雄	AMED 国際事業部 医療分野国際科学技術共同研究開発推進事業 プログラム・スーパーバイザー 国際医療福祉大学大学院　教授	2019 年 1 月 12 日～ 2019 年 1 月 21 日
計画・評価	石井　克美	AMED 国際事業部　国際連携研究課　主幹	2019 年 1 月 12 日～ 2019 年 1 月 21 日

現地調査は 2019 年 1 月 8 日から 2019 年 1 月 22 日に実施し、サイト視察、インタビュー、プロジェクト報告書等の関連文書レビューを実施した（付属資料の別添 2.参照）。

１－４　プロジェクトの枠組み

プロジェクトの枠組みを以下に示す。

(1) プロジェクト期間：2014 年 5 月 12 日から 2019 年 5 月 11 日まで 5 年間

[4] SATREPS 感染症分野プロジェクトの所掌事務及び権限は、2015 年 4 月 1 日より AMED に移管された。

（2）プロジェクト管理：本プロジェクトの管理体制は以下のとおりである。
－プロジェクト・ダイレクター：科学技術省（Department of Science and Technology：DST）バイオテクノロジー部門チーフ・ダイレクター
－プロジェクト・共同ダイレクター：国家保健省（National Department of Health：NDOH）伝染性疾患部門チーフ・ダイレクター[5]
－プロジェクト・マネジャー：気候地球システム科学応用センター（ACCESS）センター長
－チーフ・アドバイザー：長崎大学熱帯医学研究所（以下、「熱研」と記す）病害動物学分野教授

（3）プロジェクト実施機関：南アフリカ側及び日本側研究機関を示す。
1）　南アフリカ側
ACCESS、南アフリカ医学研究評議会（South African Medical Research Council：SAMRC）、南アフリカ科学・工学研究評議会（Council for Scientific and Industrial Research：CSIR）、国立伝染病研究所（National Institute for Communicable Diseases：NICD）[6]、南アフリカ気象サービス（South African Weather Service：SAWS）[7]、リンポポ州保健局（Department of Health-Limpopo：LDOH）、リンポポ州保健局（マラリア予防対策センター）（Department of Health-Limpopo, Malaria Control：LDOH-Malaria）、ケープタウン大学（University of Cape Town：UCT）、リンポポ大学（University of Limpopo：UL）、プレトリア大学（University of Pretoria：UP）[8]、ヴェンダ大学（University of Venda：UV）[9]、西ケープ大学（University of the Western Cape：UWC））
2）　日本側
熱研及び国立研究開発法人 海洋研究開発機構（以下、「JAMSTEC」と記す）

（4）裨益対象者：本プロジェクトの直接的、間接的な裨益対象者は、それぞれ南アフリカ側研究機関の研究者（57名）、リンポポ州の住民（約540万人）である。

（5）プロジェクトの要約
最新PDMであるversion 2〔2016年10月4日、第3回合同調整委員会（以下、「JCC」と記す）で改定承認〕に示されるプロジェクトの要約（プロジェクト目標、成果、活動）を以下に示す。
指標、入手手段、双方のプロジェクトへの投入、前提条件、外部条件等のその他の項目は、付属資料の別添1.PDM version 2を参照のこと。

[5] 郡保健サービス局チーフ・ダイレクターから交代した。これにしたがって、2015年11月10に科学技術省とJICAの間で了解覚書（以下、「MOU」と記す）（2014年5月12日付）を修正するための協議議事録（以下、「MM」と記す）を取り交わした。
[6] 2015年10月に開催された第2回JCCで南アフリカ側のメンバーとして承認された。
[7] 2015年10月に開催された第2回JCCで南アフリカ側のメンバーとして承認された。
[8] 2014年8月に開催された第1回JCCで外部協力機関から南アフリカ側のメンバーとして承認された。
[9] 2014年8月に開催された第1回JCCで南アフリカ側のメンバーとして承認された。

プロジェクトの要約

プロジェクト目標	南部アフリカへの適用に向けた先駆けとして、感染症対策のための気候予測に基づいた早期警戒システムモデルが確立される。
成果	成果 1 特にマラリア、肺炎、下痢症について、気候に基づいた感染症流行予測モデルが開発される。 成果 2 気候予測に基づいた感染性疾患流行早期警戒システム（iDEWS）の運用指針がリンポポ州で策定される。 成果 3 iDEWS の予測性能と運用性が実証される。
活動	活動 1 1-1. 感染症及び気候変動に関する前向き及び後ろ向きデータ/情報取得システムの構築 1-1-1. 現地の保健情報システムや医療施設の履歴情報等から得られるマラリア、肺炎及び下痢症のデータ/情報をデータベース化する。 1-1-2. データベースの過去のデータを用いて各疾患の危険度分布図を作成し、調査対象サイトを決定する。 1-1-3. 調査対象サイト内のコミュニティで各疾患の罹患率及び有病率（診断されていないものを含む)、感染症流行に影響のある住民行動（受療行動など)、衛生環境（水質、大気汚染、マラリア蚊の殺虫剤抵抗性など）の実態を調査し、データベースに組み入れる。 1-1-4. SAWS や ARC などの ACCESS パートナー機関より、気候性及び非気候性補助的環境データ（地理情報等）を入手する。 1-1-5. 公共建物に基本的気象観測ステーションを設置し、基礎的調査対象サイト内の局地的気象データを測定する。 1-2. 対象疾患の罹患率/有病率、気候変動（気温、湿度、降雨量など）の関係性の解明 1-2-1. 対象疾患の罹患率/有病率と気候変動の関連性を時系列分析により調査する。 1-2-2. マラリア媒介蚊と気候変動、そして、マラリア罹患率/有病率との関係を調査する。 1-2-3. リンポポ州の局地気候変動と、エルニーニョ南方振動（ENSO）やインド洋ダイポールモード（IOD)、亜熱帯ダイポールモード（SDM）などの地球規模の気候変動現象との関連性を分析する。 1-3. リンポポ州の感染症流行状況を反映したマラリア、肺炎、下痢症の感染症数理もしくは、統計モデルの開発 1-3-1. マラリアやコレラなどの既存の感染症モデル（特に気候に関連した）をレビューする。 1-3-2. マラリア、肺炎、下痢症の基本的数理モデル及び統計モデルを改良または新規作成する。 1-3-3. データベースで得られた感染症の後ろ向き及び前向きデータ/情報を用いてモデルの予測性能を検証し、モデルを調整する。 1-4. 大気−海洋結合モデルを用いた短期気候変動予測システム（SINTEX-F）

	の高度化（予測精度の向上、予測情報の局地的な高解像度化、予測リード期間の長期化等） 1-4-1. 空間高解像度化、物理スキーム改善、データ同化による初期化精度を向上させた新型の SINTEX-F を開発する。 1-4-2. 既存の SINTEX-F や南アフリカの気候モデル等の相互比較を通して、短期気候変動予測モデルのバイアスを低下させる。 1-4-3. SINTEX-F の地球規模季節予測情報を、力学モデル（WRF）や統計手法を用いて局地的に高解像度化し（ダウンスケーリング）、その予測性能向上や予測期間の長期化を行う。 1-4-4. 活動 1-4-3 と相互作用的に、対象地域の気候観測データ（活動 1-1 より）との相互比較を通して WRF モデルを高精度化する。 1-5. 気候に基づいたマラリア、肺炎及び下痢症の感染症流行予測モデルの開発 1-5-1. 活動 1-2 の対象疾患の罹患率/有病率、気候変動、ベクター間の関係性解析結果を踏まえ、感染症数理・統計モデルと改良気候変動予測システムを連結させて、気候に基づいた感染症流行予測モデルを作成する。 1-5-2. データベースで得られた過去数十年の感染症流行やアウトブレイクデータ/情報を用いてモデルの予測性能を検証し、モデルを調整する。 <u>活動 2</u> 2-1. 流行予測を担当する組織や流行/警戒情報発出を担当する組織、情報に基づいて対策を行う組織などによるリンポポ州 iDEWS 導入準備委員会を立ち上げる。 2-2. アウトブレイク警戒情報発令の基準を設定する。 2-3. リンポポ州内の感染症流行/警戒情報伝達方法を設定する。 2-4. 定期情報伝達方法、アウトブレイク警戒情報発令と対策行動、情報伝達フォーマット、運用組織等を含む iDEWS 運用指針を作成する。 <u>活動 3</u> 3-1. リンポポ州で iDEWS を試験運用し、iDEWS の予測性能及び運用性を評価する。 3-2. リンポポ州において、感染症アウトブレイク警戒情報発令と対策行動に係る机上訓練を実施する。 3-3. iDEWS がリンポポ州の感染症対策に及ぼす影響を分析するための持続性のあるモニタリング評価システムを作成する。 3-4. 利用可能な他州もしくは隣国の感染症流行データ、気候性及び非気候性環境データを用いて、iDEWS の適用性を検証する。 3-5. 他州や隣国への iDEWS の展開に向けて、南アフリカや隣国の気候変動や感染症対策を担当する行政官、研究者等の関係者を対象としたワークショップを開催する。 3-6. 南アフリカの気候変動や感染症対策を担当する行政官、研究者等の関係者と他州への iDEWS 展開に向けた協議を開始する。

第２章　終了時評価の方法

２－１　SATREPS におけるプロジェクト評価の枠組みについて

SATREPS は JICA による現地での技術協力プロジェクト実施協力と AMED による日本国内での技術的・財政的研究支援が連携して推進されることから、評価活動実施の効率性にかんがみ、現地調査は JICA と AMED が連携、協力して実施される。

JICA はプロジェクト運営の一環として、政府関係者・研究代表者を含めた先方協力機関等と相談しながら、ODA 事業として相手国における人材育成、能力強化及び開発課題に対する貢献の観点から評価（レビュー）を実施する。また、AMED は地球規模課題の解決に資する研究成果、科学技術水準の向上の観点から日本国内及び相手国を含めた国際共同研究全体の評価を行う。

２－２　評価手法

終了時評価は「JICA 事業評価ガイドライン第 2 版」（2014 年 5 月）及び「JICA 事業評価ハンドブック（version 1）」（2015 年 8 月）に沿って実施された。実績・実施プロセスの確認と 5 項目評価を行うための具体的な方法を検討するため、評価設問、必要な情報・データ、情報源、データ収集方法について一覧表で示した評価グリッド（付属資料の別添 3.を参照）を作成した。

評価チームのメンバーは評価グリッドに基づき、カウンターパート（Counterpart Personnel : C/P）研究者や各関係機関、JICA 専門家に対して質問票やインタビューを実施し、プロジェクトのレビューを実施した（主要面談者は付属資料の別添 4.を参照）。

PCM の常法に則り、最新の PDM version 2 に基づいて指標の達成度を含めたプロジェクト実績を確認し、評価 5 項目での評価分析を行った。終了時評価チームは、評価結果を終了時評価報告書に取りまとめた。

２－３　評価 5 項目

本終了時評価に用いた評価 5 項目の概説を以下に示す。

評価 5 項目	概　説
妥当性	プロジェクトの目標（PDM のプロジェクト目標、上位目標）が、受益者のニーズと合致しているか、援助国側の政策と日本の援助政策との整合性はあるかといった、「援助プロジェクトの正当性」を検討する。終了時評価での妥当性評価は、現状・実績に基づいて検証作業を行う。
有効性	PDM の「プロジェクトの成果」の達成度合いと、それが「プロジェクト目標」の達成にどの程度結びついたかを検討する。終了時評価での有効性評価は、現状・実績に基づいて検証作業を行う。
効率性	プロジェクトの「投入」から生み出される「成果」の程度を把握する。各投入のタイミング、量、質の適切度を検討する。終了時評価での効率性評価は、現状・実績に基づいて検証作業を行う。
インパクト	プロジェクトが実施されたことにより生じる直接・間接的な正負の影響を検討する。終了時評価でのインパクト評価は、予測・見込みに基づいて検証作業を行う。
持続性	援助が終了した後も、プロジェクト実施による便益が持続されるかどうか、自立発展に必要な要素を見極めつつ、プロジェクト終了後の自立発展の見通しを検討する。終了時評価での持続性評価は、予測・見込みに基づいて検証作業を行う。

第３章　プロジェクトの実績と実施プロセス

３－１　投入

（1）日本側投入実績

以下に、2019 年 1 月時点のプロジェクトに対する日本側からの投入を示す。詳細は付属資料の別添 5.を参照のこと。

構　成	投　入
日本人専門家の派遣	長期専門家：合計 3 名（疫学・医用昆虫学、業務調整）、101 人/月 短期専門家：合計 16 名、71.7 人/月（延べ 1,148 日間）
資機材の提供	内容：自動気象観測装置、顕微鏡や人工環境装置、マラリア診断装置などの研究機器、解析用パーソナルコンピュータ、解析用ソフトウェアなど（合計 3,382 万 5,724 円）
外国人研究員の招へい	延べ 35 名、合計 347 日間 協議内容：南部アフリカ地域気候変動予測に関する研究打合せ及びプロジェクト公開シンポジウム参加・発表と研究打合せ
本邦研修	合計人数：7 名 研修内容： －地理情報システム（GIS）を用いた感染症危険分布図作成のための統計学的解析手法の理論と実践（2 名、熱研、22 日間） －感染症の発生件数と気象データ間の相関解析に関する統計学的解析手法の理論と実践（1 名、JAMSTEC、21 日間） －気象観測統計及び気候変動の理論と統計学的解析手法の研修（3 名、JAMSTEC、30 日間） －感染症件数データの品質管理及びクリーニング、サンプル解析（1 名、JAMSTEC、14 日間）
在外事業強化費	合計：2,720 万 7,690 円 －2014 年度：389 万 9,227 円 －2015 年度：593 万 234 円 －2016 年度：574 万 6,216 円 －2017 年度：660 万 8,388 円 －2018 年度：502 万 3,625 円 支出内容：国内旅費・交通費、研究用消耗品費、通信費など

（2）南アフリカ側投入実績

以下に、2019 年 1 月時点のプロジェクトに対する南アフリカ側からの投入を示す。詳細は付属資料の別添 5.を参照のこと。

構　成	投　入
C/P 配置	合計 57 名の研究者、行政官、技術者等 1. 気候地球システム科学応用センター（ACCESS）：1 名 2. 南アフリカ医学研究評議会（SAMRC）：14 名

	3. 南アフリカ科学産業研究評議会（CSIR）: 8 名[10] 4. 国立感染症センター（NICD）: 1 名 5. 南アフリカ気象局（SAWS）: 6 名 6. リンポポ州保健局 : 2 名 7. リンポポ州保健局（マラリア）（LDOH-Malaria）: 4 名 8. ケープタウン大学（UCT）: 3 名 9. リンポポ大学（UL）: 8 名 10. プレトリア大学（UP）: 4 名 11. ヴェンダ大学（UV）: 4 名 12. 西ケープ大学（UWC）: 2 名
施設及び資機材	1. CSIR 及び LDOH-Malaria 内プロジェクト事務所スペース 2. LDOH-Malaria 内実験・事務所スペース 3. 南アフリカ国内の全プロジェクト参画機関の既存の機器 4. プロジェクトに関係する利用可能なデータ、情報及び検体 5. CSIR 内テレビ会議システムの使用
現地活動費	・南アフリカ DST は本プロジェクトに対して合計 ZAR 5,700,000（約 4,581 万 3,000 円[11]）を提供し、国内出張や現地活動、機器等の購入に使用された。また、一部は iDEWS 事務局の設立準備に使用されている。 ・ACCESS は本プロジェクトの下で研究活動を行う現地の学生（博士課程名、修士課程 2 名）に奨学金を提供した。 ・リンポポ州でのフィールド調査経費、入院患者情報データベース化のための経費、南アフリカ側 C/P 国内旅費・交通費、プロジェクト活動に必要な消耗品、プロジェクト事務所水道光熱費、研究機器や試薬など本邦調達物品の輸入通関費など。

３－２　プロジェクトの実績

（1）プロジェクト活動の実績

成果に係るプロジェクト活動実績を以下に示す。

成果 1 特にマラリア、肺炎、下痢症について、気候に基づいた感染症流行予測モデルが開発される。	
活　動	達成事項
1-1. 感染症及び気候変動に関する前向き及び後ろ向きデータ/情報取得システムの構築	
1-1-1. 現地の保健情報システムや医療施設の履歴情報等から得られるマラリア、肺炎及び下痢症のデータ/情報をデータベース化する。	・LDOH-Malaria と熱研主導で、迅速診断検査キットを用いた診断が行われた 1998 年以降のリンポポ州のマラリア患者発生データを収集し、汎用ソフトを用いてデータベース化した。また、中間レビュー以降、プロジェクトは予測モデルが使用する変数のデータベースに携帯電話通信網を用いて毎日自動で転送できるシステムを構築した。また、携帯電話を使ったマラリア患者報告システムにより集められたデータも準リアルタイムでデータベースに自動転送できるようにした。このようなデータの自動転送システムが構築されたことにより、データ入力の省力化や

[10] うち 1 名が 2019 年 1 月にヴィットウォーターズラント大学ヨハネスバーグに異動となった。
[11] 2019 年 1 月 28 日時点の為替レートを用いて概算した。

	入力エラーの防止に貢献するとともに、予測モデルで使用するデータも常に最新のものとなり、予測精度や品質管理の維持向上に大きく貢献するものと考えられる。 マラリア患者発生データは随時追加されており、2018 年 12 月時点で、約 12 万件が登録されている。 ・下痢症及び肺炎に関するデータ収集について SAMRC と ACCESS 主導でグレーター・ギアニ地区のケンサニ病院とファラボルワ地区にあるバ・パラボルワ病院の全入院患者情報 44,159 件（2002～2016 年）のデータベースへの登録とデータの品質向上作業（データ・クレンジング等）を終了した。 ・ACCESS は独自に保険会社から下痢症及び肺炎の病名での保険請求情報を 6 万～8 万件入手している。また、病院を受診しない程度の軽症例を反映するデータとして、止瀉薬（一般薬のロペラミド）販売量のデータも入手した。 ・マラリアに関するデータベース化は順調に進捗しているが、下痢症と肺炎情報のデータベース化は、南アフリカ側活動費が利用可能となった時期が想定より遅れたことや、膨大な紙ベースの情報の電子化作業に時間を要していることなどにより、中間レビュー時点で予定よりおおむね 6 カ月～1 年程度の遅れが生じていたが、分析のためのデータベース化は 2017 年 4 月までに完了している。
1-1-2. データベースの過去のデータを用いて各疾患の危険度分布図を作成し、調査対象サイトを決定する。	・データベースの情報を用いて、LDOH-Malaria と熱研はマラリア感染危険度分布図を作成した。プロジェクトは分布図に基づき、集中調査対象地域にグレーター・ギアニ地区とベンベ地区を選定した。 ・下痢症及び肺炎についてはマラリアのように感染者のホットスポットがあるような疾患ではなく州全体でほぼ均一に発生すると考えられるため、活動の効率性を考慮し、グレーター･ギアニ地区を対象地域として関係者協議のうえで決定した。
1-1-3. 調査対象サイト内のコミュニティで各疾患の罹患率及び有病率（診断されていないものを含む）、感染症流行に影響のある住民行動（受療行動など）、衛生環境（水質、大気汚染、マラリア蚊の殺虫剤抵抗性など）の実態を調査し、データベースに組み入れる。	・LDOH-Malaria、SAMRC 及び熱研は、2015～2016 年シーズンよりグレーター・ギアニ地区のコミュニティにおいて、LAMP 法による無症候性マラリア感染状況の調査を約 500 世帯のコミュニティ住民に対して実施した。この調査では実際に検知できた感染者数は少なかったが、無症候性マラリア感染者の有病率調査を実施するための手順や実施体制を確定した。 特に南アフリカのような排除に近いレベルでマラリア報告患者数が減少している場合、無症候性マラリア感染者の有病率情報は、感染者の報告が著しく減少しても本当にアウトブレイクのリスクがなくなったのかを評価するために必要な情報である。また、報告患者数が減少するとモデルの予測精度が低下するため、無症候性マラリア感染者の有病率情報は報告患者数が低下した際の予測モデルの予測精度維持に必要な情報である。 ・また、同地区での殺虫剤屋内残留噴霧（Indoor Residual Spraying：IRS）実施状況に関する情報を調査し、データベースに取り入れた。 ・マラリア媒介蚊（ハマダラカ）の捕獲装置を 2015～2016 年シーズンに設置したが、密度が少ないため実験を行うだけの媒介蚊の成虫を採取できず、殺虫剤抵抗性等の研究は実施できなかった。そのため、

	LDOH-Malaria にある過去のデータや他のグループの研究成果などを予測モデル開発に活用した。なお、抵抗性に関する情報はマラリア流行予測モデル開発のためではなく、むしろ iDEWS の下で予防対策を行うための情報として活用される見込みである。 ・他方、プロジェクトは SAMRC 主導で 2015～2016 年シーズンからコミュニティでの感染症流行に影響のある住民行動や、特に肺炎や下痢症の発生に影響する衛生環境、大気汚染などの状況の調査を 3 回実施した。これらの分析結果も予測モデル開発のための変数としてではなく、気候変数と感染症流行との因果関係の解釈もしくは説明や、患者数増加が予測された際の対策を講じるための基礎情報として活用されることが想定されている。
1-1-4. 南アフリカ気象サービス（SAWS）や農業研究評議会（ARC）などの ACCESS パートナー機関より、気候性及び非気候性補助的環境データ（地理情報等）を入手する。	・熱研、JAMSTEC 及び UL は、衛星観測による気象性データ、及び地理情報などの非気象性補助的環境データを協力機関等から入手し、既存の大気–海洋結合モデルを用いた短期気候変動予測モデル（SINTEX-F）の高度化（SINTEX-F2 の開発）や感染症危険度分布図作成に活用した。 ・また、気象の地上観測データは ARC 及び SAWS により提供されることを想定していたが、ARC からデータ提供の協力は得られなかった。SAWS についてはデータ提供に必要な契約に想定以上の時間がかかったが、2016 年 8 月に契約が締結され、データ入手が可能な状況となっている。なお、地上観測データはダウンスケーリングされた気候予測性能検証に使用されたため、この遅延が SINTEX-F2 開発そのものには影響していない。 ・なお、SAWS はプロジェクト開始当初は外部協力機関であったが、2015 年 10 月の第 2 回 JCC でプロジェクトの実施機関として承認されている。
1-1-5. 公共建物に基本的気象観測ステーションを設置し、基礎的調査対象サイト内の局地的気象データを測定する。	・2015 年までに、ACCESS、LDOH-Malaria 及び熱研は、自動気象観測装置 7 台を調査重点地区であるグレーター・ギアニ域内の医療施設に設置し、気象の地上観測データ収集が実施されている。 ・なお、SAWS から得られる気象の地上観測データは南アフリカ全土をカバーしているのに対し、プロジェクトで設置した観測装置は調査重点地域の気象データを詳細かつ即時的に収集できる。 ・プロジェクト期間終了後も気象の地上観測データ収集及び装置のメンテナンスは、iDEWS 事務局（後述）の下で南アフリカ側実施機関によって継続されることが見込まれている。
1-2. 対象疾患の罹患率/有病率、気候変動（気温、湿度、降雨量など）の関係性の解明	
1-2-1. 対象疾患の罹患率/有病率と気候変動の関連性を時系列分析により調査する。	・熱研と JAMSTEC は、1998 年以降のリンポポ州におけるマラリア患者数と気候との関連を複数の時系列統計手法を使って分析し、相関性があることを明らかにした。具体的には、マラリア患者数とモザンビーク及びジンバブエ南部の降水量及び東風との正の相関や、ペルー沖の海面温度との負の相関（ラニーニャとの正の相関）を明らかにしている。また、これらの相関性の季節ごとの解析も実施した。 ・下痢症に関して、中核病院からの下痢症患者数データと気候変数を輪郭解析という手法で分析した結果、冬期に連続して降雨がないか（干ばつになる）、連続して降雨があると、5 歳以下の子どもの下痢症件数が増加する傾向があることがわかり、その相関は 8 週間のラグを入れると高く

	なった。また、エルニーニョ現象が発生していた2010～2011年及び2015年に下痢症患者数の増加傾向が観察された。一般的に、エルニーニョが発生すると南部アフリカは干ばつになる傾向がある。 さらに、保険会社の下痢症の保険請求件数にも同様の傾向がみられ、止瀉薬（ロペラミド）の過去10年間の販売量もエルニーニョ現象及びモザンビーク海峡の海水面温度との間で統計的に有意な負の相関性が観察された。これは、モザンビーク海峡の海水面温度が低下すると、南部アフリカの降水量が減少する傾向があるためと思われる。また、下痢症に対する保険請求件数はインド洋亜熱帯ダイポールモード現象と連動しており、負のモード（南部アフリカ近辺の海水面温度が相対的に低下する）が発生すると、エルニーニョが発生していなくとも下痢症の保険申請件数が増加傾向にあることが明らかになった。 ・肺炎については、発生数と海面水温に有意な相関関係はみられなかった。そこで、肺炎発生数の多い年に焦点を当てて合成解析を行ったところ、肺炎患者数の多い年には気温の日較差が平年に比べ大きいことが明らかになった。このことは、日中の最高気温と夜間の最低気温の差が広がるほど、肺炎患者数が高くなることを示唆している。とはいえ、肺炎患者数と相関性が認められた気象変数は気温のみであった。
1-2-2. マラリア媒介蚊と気候変動、そして、マラリア罹患率/有病率との関係を調査する。	・活動1-1-3で示したとおり、これまでにマラリア媒介蚊の成虫を解析が行える程度に採取できておらず、マラリア媒介蚊と気候変動や罹患率との関連についての解析は実施できていない。一方、幼虫発生源の季節変動と気象との関係を分析した。 ・プロジェクトはマラリア感染に直接影響する成虫の媒介蚊の観測システムは構築できなかったが、幼虫発生源を合計29カ所特定できたことから、幼虫の観測システムは構築することができた。プロジェクトの分析から媒介蚊の発生源の遷移が気候変数と相関する可能性が示唆されており、引き続き、関連データを蓄積している。この相関性が証明されれば、関連データを予測モデルの変数として活用することにより、より予測精度の向上が見込まれる。 ・また、プロジェクトはザニンマラリア研究所（Tzaneen Malaria Institute : TMI）における人工環境装置を用いた室内実験によって、マラリア媒介蚊（雌成虫）の体長（羽の長さ）及び産卵数が気温と強く相関することを確認した。この知見は南アフリカ側が主導して開発を進めている数理モデルに基づくマラリア流行予測モデルの開発に活用されている。
1-2-3. リンポポ州の局地気候変動と、エルニーニョ南方振動（ENSO）やインド洋ダイポールモード（IOD）、亜熱帯ダイポールモード（SDM）などの地球規模の気候変動現象との関連性を分析する。	・JAMSTECはSINTEX-F2を用いて、リンポポ州を含む南部アフリカ地域の気候がラニーニャ現象とインド洋ダイポールモード現象及び亜熱帯ダイポールモード現象の影響を受けやすいことを示し、そのメカニズムがより明らかになった。さらに、亜熱帯ダイポールモード現象を引き起こす亜熱帯高気圧の変動に、南極ウェッデル海の海氷変動もまた影響を及ぼすことが示唆された。 ・また、JAMSTECは気候観測データの解析から、南部アフリカ地域の降水量が季節変動や年々変動だけではなく、10年規模でゆっくり変動していることを明らかにした。また、SINTEX-F2を用いた解析により、この10 年規模の変動は南太平洋から南インド洋に東進する海面気圧と海面水温の10年規模変動と強く相関していることが明らかとなった。

	・なお、プロジェクトは、上述の南部アフリカ地域での 10 年規模の気候変動とリンポポ州のマラリア患者発生件数との正の相関関係の可能性を指摘しており、詳細な解析を実施した。その後の研究で、インド洋の南西部における海面水温の 10 年規模変動（マダガスカルの東方沖と南方沖に正と負の海面水温偏差を伴う）が、降水量の変動を通してベンベ地区のマラリア発生数に 10 年規模変動をもたらしていることが明らかになった。
1-3. リンポポ州の感染症流行状況を反映したマラリア、肺炎、下痢症の感染症数理もしくは、統計モデルの開発	
1-3-1. マラリアやコレラなどの既存の感染症モデル（特に気候に関連した）をレビューする。	・感染症発生件数の予測モデルには多くの手法があり、過去の感染症発生件数と気候データについて因果推論する統計モデルと、さまざまな現象（本件では感染症発生件数）を数式で表現することにより性質を推論する数理モデルがある。熱研と JAMSTEC は、マラリア、肺炎及び下痢症に関する既存の感染モデルのレビューをプロジェクトの前半で実施した。 ・レビューの結果、肺炎及び下痢症に関しては、統計モデルが中心であった一方、マラリアに関しては、ロス・マクドナルドモデル（マラリア流行の数理モデル）から派生した数理モデルが複数あり、そのなかでも最も新しい VECTRI モデルは、媒介蚊の生態も考慮しており、製作者とコンタクトし、プログラム情報を得た。
1-3-2. マラリア、肺炎、下痢症の基本的数理モデル及び統計モデルを改良または新規作成する。	・熱研と JAMSTEC は、マラリア感染件数の時系列解析や機械学習手法を基に、リンポポ州の降雨量、気温やその他の環境変数を考慮したいくつかの統計モデルを開発した。また、JAMSTEC は上述の VECTRI モデルに気象因子を含めた数理モデルの開発を行った。VECTRI モデルを用いて 1998～2015 年まで再予測実験を行ったところ､2 月のベンベ地区におけるマラリア発生数を予測できることがわかった。このモデルは感染したら非常に高い予測性を得られる可能性があるが、現時点では実用レベルにまでは達しておらず、プロジェクト期間終了後も開発作業を継続する予定である。 ・南アフリカ側の感染症流行モデル開発を担当する UWC でも、日本側の研究と並行してマラリア流行の数理モデルの開発を行っている。これまでに 2 報の学術論文を国際誌に発表している。 また、UP では独自のアンサンブル気候予測に基づくマラリア流行の線形統計モデルを開発し、その予測性能は実用レベルに達している（実測値と予測値の相関係数は 0.8）。下痢症についても必要なデータが提供されれば、モデル開発を検討する予定である。 ・活動 1−2−1 で示したとおり、肺炎と下痢症について、それぞれ患者数の増加と気候変数との相関解析を実施した。下痢症については複数の気候変数や気候現象との相関性が確認されたため、予測モデルが開発できることが明らかとなった。現在、プロジェクトは下痢症についての予測モデル開発の初歩的な検討を開始した段階である。しかしながら、肺炎に関しては、患者数と相関が認められた気象変数が気温のみであり、さらに気温の日較差の予測を行うことは技術的に困難であることから、現時点では肺炎については気候に基づいた流行予測モデルの開発が困難であることが明らかとなった。

<table>
<tr><td>1-3-3. データベースで得られた感染症の後ろ向き及び前向きデータ/情報を用いてモデルの予測性能を検証し、モデルを調整する。</td><td>・マラリア流行予測モデル開発を行っている熱研と JAMSTEC 及び UWC は、後ろ向き及び前向きのマラリア患者データ/情報を用いてマラリア流行予測モデルの予測性能を検証し、モデルを調整した。
・下痢症についても、流行予測モデルが完成次第、予測性能の検証、モデルの調整を実施する予定である。ただし、終了時評価時点ではモデル開発の検討を開始した段階であり、2019 年 5 月のプロジェクト期間終了までにこれらの作業を完了することは困難である見込みである。しかしながら、南アフリカ側・日本国側双方の研究機関は設立予定である iDEWS 事務局の下で開発作業を継続する意思を表明している。</td></tr>
<tr><td colspan="2">1-4. 大気−海洋結合モデルを用いた短期気候変動予測システム（SINTEX-F）の高度化（予測精度の向上、予測情報の局地的な高解像度化、予測リード期間の長期化等）</td></tr>
<tr><td>1-4-1. 空間高解像度化、物理スキーム改善、データ同化による初期化精度を向上させた新型の SINTEX-F を開発する。</td><td rowspan="2">・JAMSTEC は先行 SATREPS プロジェクトで開発した SINTEX-F に基づき、南極の海氷の影響を考慮し、高解像度化した新型の SINTEX-F2 を 2015 年に開発した。さらに、海洋亜表層に関して、データ同化による初期値精度を向上させた。その結果、南インド洋で発生する亜熱帯ダイポールモード現象や熱帯インド洋で発生するインド洋ダイポールモード現象の予測精度が改善するとともに、南アフリカの夏期降水量の予測精度が向上した。さらに、予測期間を 10 年先まで延ばすことにより、アフリカ南部の降水量に長期変動をもたらす、南インド洋と南大西洋の海面水温にみられる 10 年規模変動を SINTEX-F2 モデルで予測できることが明らかになった。
さらに、SINTEX-F2 季節予測システムを発展させ、予測シミュレーションされるパラレルワールドの数（アンサンブルともよぶ）を 108 まで増やした。このような非常に多くのアンサンブルによる季節予測シミュレーションは世界初である。その結果、より多くの予測シグナルの検出や、より緻密な確率密度関数の予測が可能となった（エルニーニョ南方振動やインド洋ダイポールモード、その他の気候変動の極端イベントに対する予測でのメリットを確認済み）。確率論的予測を発展させるためにも大いに役立つ。
・開発自体は終了しているが、今後も引き続き既存の気候モデル等との相互比較を継続し、予測スキルの向上を行うとしている。
・また、南アフリカ側研究機関の CSIR 及び UP は JAMSTEC と並行して短期気候変動予測システムの開発を行っており、JAMSTEC との情報交換や技術交流によって改良を継続している。
・なお、複数の予測モデルを集約し、両国のマルチモデルによるアンサンブル予測を配信するシステムの開発を行うことを双方合意している。</td></tr>
<tr><td>1-4-2. 既存の SINTEX-F や南アフリカの気候モデル等の相互比較を通して、短期気候変動予測モデルのバイアスを低下させる。</td></tr>
<tr><td>1-4-3. SINTEX-F の地球規模季節予測情報を、力学モデル（WRF）や統計手法を用いて局地的に高解像度化し（ダウンスケーリング）、その予測性能向上や予測期間の長期化を行う。</td><td>・JAMSTEC と CSIR は、SINTEX-F2 の地球規模季節予測情報を $10km^2$ の範囲を予測するダウンスケーリングに成功した。JAMSTEC と CSIR はその力学的ダウンスケーリングモデルの性能を共同で試験したところ、複雑な地形の影響を受ける南アフリカの気温や降水量に関する予測の精度が向上していることを確認した。
・さらに、中間レビューまでに SAWS の気象地上観測データが利用可能となったことから、衛星からの観測データを基に地上観測データも使用して、更なる予測性能や予測リードタイムの向上に向けた研究を継続している。</td></tr>
</table>

1-4-4. 活動 1-4-3 と相互作用的に、対象地域の気候観測データ（活動 1-1 より）との相互比較を通して WRF モデルを高精度化する。	・また、UP は独自のアンサンブル予測による気候変動予測システムを開発し、その後、予測のダウンスケーリングにも成功した。これらの研究成果はそれぞれ国際誌に論文として発表されている。 ・領域気候モデル WRF を用いて、SINTEX-F2 の予測結果をダウンスケールし、統計手法を用いて WRF モデルのバイアスを修正した。ダウンスケールしたデータは、VECTRI モデルや長崎大学のマラリア統計モデルを駆動するために利用された。また、マラリアの発生時期に影響を及ぼす、南アフリカの雨期の開始時期を調べる研究にも応用された。
1-5. 気候に基づいたマラリア、肺炎及び下痢症の感染症流行予測モデルの開発	
1-5-1. 活動 1-2 の対象疾患の罹患率/有病率、気候変動、ベクター間の関係性解析結果を踏まえ、感染症数理・統計モデルと改良気候変動予測システムを連結させて、気候に基づいた感染症流行予測モデルを作成する。	・熱研と JAMSTEC は、力学的ダウンスケーリングによって提供された気候予測データをマラリア流行予測モデルと連結させた「気候に基づいたマラリア流行予測モデル」の開発を 2016 年度より開始した。 ・熱研と JAMSTEC はマラリア流行を予測する実用性の高い 2 つの基本的なモデル（熱研が非線形統計モデル、JAMSTEC が機械学習を基にしたモデル）を開発した。それぞれの予測精度や特徴は別途説明するが、両方のモデルともマラリア流行の予防対策に使用するのに十分な予測精度が得られており、プロジェクトとしてマラリア流行予測モデルの開発は完了できたといえる。 ・また、UP は独自のアンサンブル気候変動予測システムに基づいたマラリア流行予測統計モデルを開発した。このモデルはマラリア流行シーズンの 1 カ月前（すなわち 11 月）に 1 月～3 月までの 3 カ月全体の予測を精度高く提供し、患者数の予測値と実測値の相関係数は 0.8 と非常に高い。終了時評価時点で UP はこの研究結果にかかわる論文を執筆作業中である。 なお、現時点では数理モデルの開発は JAMSTEC が VECTRI モデルを、UWC が数理モデルの開発を行っているが、現時点では実用レベルには達していない。今後も継続して改良のための研究が継続される見込みである。 ・他方、前述のとおり、下痢症については患者数と気候変数や気候現象との相関性が確認され、気候予測に基づく流行予測のモデル開発が開始された段階であり、プロジェクト期間終了後も iDEWS 事務局によって開発作業が継続される見込みである。 しかしながら、肺炎については、現時点では技術的に気候予測に基づいた流行予測モデルの開発は困難であることが明らかとなった。
1-5-2. データベースで得られた過去数十年の感染症流行やアウトブレイクデータ/情報を用いてモデルの予測性能を検証し、モデルを調整する。	・熱研と JAMSTEC は過去のマラリアデータを基に 2 つのモデルの予測性の検証と微調整を実施し、モデルとして完成させている。 ・活動 1-3-3 で示したとおり、肺炎についても、流行予測モデルが完成次第、予測性能の検証、モデルの調整を実施する予定である。

成果 2 気候予測に基づいた感染性疾患流行早期警戒システム（iDEWS）の運用指針がリンポポ州で策定される。	
活　動	達成事項
2-1. 流行予測を担当する組織や流行/警戒情報発出を担当する組織、情報に基づいて対策を行う組織などによるリンポポ州 iDEWS 導入準備委員会を立ち上げる。	・2015 年 10 月に iDEWS 導入準備委員会設立のための協議が、南アフリカ側、日本側の研究機関間で開始された。2016 年 4 月には両国の研究者間で 2 回目の協議が行われ、運営規約（TOR）案や、委員会メンバーの選定等を実施した。 ・2017 年 1 月に正式に iDEWS 導入準備委員会が発足した。南アフリカ側の参画機関は、LDOH、国家保健省（NDOH）、SAMRC、CSIR、SAWS、NICD 等であり、日本側研究者は、アドバイザーとして参加している。終了時評価までに合計 4 回 iDEWS 導入準備委員会が開催されている。2017 年 7 月の第 2 回準備委員会では各担当機関の役割や今後の計画が協議され、2017 年 9 月の第 3 回準備委員会では、マラリア流行予測モデルのリンポポ州におけるマラリア対策への試験適用計画が協議された。2018 年 3 月の第 4 回準備委員会では 2018～2019 年シーズンの予測結果の報告と、予測結果に基づく対応等が協議された。
2-2. アウトブレイク警戒情報発令の基準を設定する。	・iDEWS 導入準備委員会をリンポポ州で開催し、マラリア流行予測情報伝達方法（アウトブレイク警報を含む）、提供基準の設定などの運用指針の作成作業を行った。当初はマラリアアウトブレイクの早期検出に基づく警戒情報の発令によるアウトブレイク発生予防や早期封じ込めのための対応実施を行うことを想定していたが、流行予測の特性やモザンビーク等のマラリア高侵淫国と比較すると患者数の少ないリンポポ州での運用を考慮した場合、個別のアウトブレイク警戒情報を発令するのではなく、原則的には定期的な流行予測情報を発表し、運用指針等に従った対応を行うことを関係者間で合意している。 ・警報発令基準については、マラリア流行の予測値を患者数として提供することは技術的に可能ではあるものの、患者の実数を告知しても比較する対象がないと判断が主観的になるため、過去のある一定期間の患者数を基準に警戒度をカテゴリーに分けて発令することにした。 具体的には、非線形統計モデルに基づく予流行測情報は、9 月から翌年の 5 月までのマラリアの流行シーズンの過去の平均的な患者数を基準として警戒度を 4 段階（低い、中程度、やや高い、高い）に分けて、週ごとに 16 週間の予測情報を出すこととしている。 一方、機械学習を基にした予報は、1 年を通して月 1 回の頻度で、四半期単位で 3 カ月間の予報を出すこととしている。基準は過去の各月の平均的な患者数を基に警戒度を 6 段階（レベル 1～6）に分けて予測情報を出すこととしている。 ・これら 2 つの予測モデルの特徴として、非線形統計モデルは週単位で予測計算を行っていることから直近の予想精度が高く、特にマラリアの流行シーズンの流行予測の精度が高い。一方、機械学習を基にした予測モデルは 1 年間を通した月ごとの予測が可能であるとともに、長期予報の精度がより高いなどの特徴がある。よって、2 つのモデルの特徴を考慮して予測結果を検討することにより、より適切な予測判断が可能となるものと考えられる。

2-3. リンポポ州内の感染症流行/警戒情報伝達方法を設定する。	・警戒情報の発令や予測情報の提供に関して法的考慮を行ったところ、その実行には既存の公的システムにのったかたちで行うことが必要であることが明らかとなったため、公的責任機関である NICD 及び SAWS をプロジェクトは協力期間の前半でプロジェクトのメンバーとした。今後設立予定である iDEWS 事務局は NICD や SAWS の支援の下で活動を行うことが想定されており、警戒情報や予測情報はそれらの機関の公的チャンネルを通して提供されることが見込まれる。 ・終了時評価までに iDEWS 導入準備委員会を合計 4 回リンポポ州で開催し、提供基準の設定やマラリア流行予測情報伝達方法（アウトブレイク警報を含む）等のマラリア流行予測結果に基づく対策の試験実施方法等を検討した。 ・予測情報は電子メールで要約情報を非公式かつ試験段階のものとして関係機関におおむね月 1 回の頻度で送付している。2018 年 1 月にプロジェクトはリンポポ州のマラリア対策に従事するスタッフ合計 30 名を対象としたワークショップを開催し、2018 年のマラリア季節流行予測の共有や予測情報の活用について協議を行った。 ・ネット上で予測データを視覚的に参照できるようなアプリを熱研がプロトタイプとして開発した。技術的にはおおむね完成しており、予測情報もアプリに自動更新されるように設計されている。公表対象範囲の検証は今後引き続き実施する予定である。
2-4. 定期情報伝達方法、アウトブレイク警戒情報発令と対策行動、情報伝達フォーマット、運用組織等を含む iDEWS 運用指針を作成する。	・iDEWS 運用指針の作成にかかわる情報は以下の活動 3-3 を参照のこと。

成果 3
iDEWS の予測性能と運用性が実証される。

活　動	達成事項
3-1. リンポポ州で iDEWS を試験運用し、iDEWS の予測性能及び運用性を評価する。 3-2. リンポポ州において、感染症アウトブレイク警戒情報発令と対策行動に係る机上訓練を実施する。	・熱研が開発した非線形統計モデル及び JAMSTEC が開発した機械学習に基づくモデルで、約 20 年ぶりとなる比較的大きな流行となった 2016～2017 年流行シーズンで後ろ向き予測したところ、予測値と実測値に高い相関性が得られ、実用化レベルに達している可能性が高いと判断された。 ・この結果を受け、リンポポ州政府はプロジェクトに対して 2017～2018 年マラリア流行シーズンの流行予測情報の提供依頼を行った。そのため、プロジェクトは机上訓練は実施せず、試験的には流行予測情報に基づき、対策実施方法や情報伝達方法、情報共有の範囲等を関係者間で検討し、LDOH 主導で予測されたホットスポットに対する 2 回目の IRS 実施や住民に対する啓発などの介入活動が実施された。この介入結果をプロジェクトが予備的に解析したところ、介入によりマラリアによる死亡率が低下した可能性が示唆され、マラリア患者数も予測より減少した。一方、患者数と死亡率の低下は住民の受診行動や検査・治療の改善によるものとも考えられる。追加で実施された IRS や環境保健員への情報共

	有などの予測情報に基づく介入の効果を科学的に実証することは現状では困難であり、今後の分析には隣国からの流入の影響や IRS 使用薬剤への蚊の耐性獲得、その他さまざまな影響を考慮する必要がある。
3-3. iDEWS がリンポポ州の感染症対策に及ぼす影響を分析するための持続性のあるモニタリング評価システムを作成する。	・このように、予測結果に基づいてどのような介入行動をどのように実施するかについては、更に科学的視点をもった検討を継続する必要性があることが確認された。南アフリカ側は日本側研究機関の技術的協力を受けながら iDEWS 委員会を立ち上げる予定であり、気候予測に基づいたマラリア流行予測によるマラリア対策の効果のエビデンスを構築するとともに、具体的な運用指針や各種フォーマット等の整備をプロジェクト期間終了後も継続して実施する予定である。
3-4. 利用可能な他州もしくは隣国の感染症流行データ、気候性及び非気候性環境データを用いて、iDEWS の適用性を検証する。	・JAMSTEC が開発した SINTEX-F2 はリンポポ州だけでなく、モザンビークやジンバブエを含む南部アフリカ地域を広範囲に高精度で気候予測することが可能となっている。また、プロジェクトは既にモザンビークからマラリア流行データを提供してもらい検証を行ったところ、既に完成している 2 つのモデルでモザンビーク南部のマラリア流行を十分な精度で予測できることが確認されている。日本側研究機関はプロジェクト期間終了後もモザンビークの関連機関との協力関係、共同研究を維持、発展させる計画である。 ・他方、南部アフリカ開発共同体（SADC）の下でマラリア排除に向けて南部アフリカ 8 カ国[12]によって 2007 年に設立された“Southern Africa Malaria Elimination 8 Initiative”（以下、“Elimination 8”と記す）は気候予測に基づくマラリア流行予測のメンバー国での適用に大きな関心を示しており、終了時評価時点では具体的な協力の方法等に関する協議が開始されている。“Elimination 8”を通じて南部アフリカ各国との協力が開始できれば、それぞれの国のマラリア流行データも収集、検証することで、気候予測に基づいた流行予測モデルを大きく展開できる可能性は高いと考えられる。 ・なお、非気候性環境データを用いた iDEWS の適用性検証は実施していないが、予測情報に基づく対策を検討する際に活用できるものと考えられる。
3-5. 他州や隣国への iDEWS の展開に向けて、南アフリカや隣国の気候変動や感染症対策を担当する行政官、研究者等の関係者を対象としたワークショップを開催する。	・これまでにプロジェクトでは以下のようなシンポジウムやワークショップ等を実施した。 ・プロジェクト主催シンポジウム・ワークショップ（キックオフシンポジウム、研究シンポジウム、研究ワークショップ等）: 2014 年 8 月プレトリア開催（42 名）、2015 年 1 月長崎開催（50 名）、2015 年 10 月プレトリア開催（32 名）、2018 年 11 月東京・横浜開催（75 名） ・LDOH 及び現地医療関係者を対象にした LDOH-Malaria でのマラリア流行感染症予測報告ワークショップ : 2014 年 10 月開催（32 名）、2018 年 1 月開催（26 名）、2018 年 6 月（LDOH 開催、30 名）、2019 年 1 月開催（15 名） ・南アフリカ国内の修士課程学生を対象としたレクチャーシリーズ : 2015 年 10 月（3 日間、66 名）、2018 年 3 月（2 日間、50 名）

[12] 2020 年までにマラリア排除をめざす 4 カ国（ボツワナ、ナミビア、南アフリカ、スワジランド）と 2030 年までに排除に向けた道筋をつける 4 カ国（アンゴラ、モザンビーク、ザンビア、ジンバブエ）

	・他州及び隣国への展開に向けたミーティング及びワークショップ：2015年1月開催（SADC主催）、2016年9月開催（モザンビーク大使館関係者参加）、2017年4月（SADC主催）
3-6. 南アフリカの気候変動や感染症対策を担当する行政官、研究者等の関係者と他州へのiDEWS展開に向けた協議を開始する。	・プロジェクトで開発した気候予測に基づいた流行予測モデルは高い予測性能を示し、2017/2018 年シーズンに実施された予測情報に基づく対策活動の試験的実施により、これらのモデルが実用レベルに達している可能性が示された。この結果を受け、iDEWS 運用準備委員会の参画機関を含めた関係機関（実施機関：NICD、SAWS、CSIR、SAMRC、UP、LDOH、協力機関：DST、ACCESS、NDOH）がマラリアを含む感染症流行の定期予測情報の提供を行う「iDEWS 事務局」の設立をめざす宣言文書に合意した（2018 年 11 月 15 日に東京で署名式が実施された）。（別添 6.を参照） ・プロジェクトの日本側実施機関である熱研と JAMSTEC はプロジェクト期間終了後も継続して iDEWS 事務局に対して技術支援を継続する意向を示しており、宣言文書にも JICA とともに立会人署名を行っている。

（2）成果の達成

1）　成果 1

成果 1 の達成度を以下に示す。

【成果 1】 特にマラリア、肺炎、下痢症について、気候に基づいた感染症流行予測モデルが開発される。	
指　標	達成度
1-1. 終了時評価時点までに、マラリアのアウトブレイクの予測確率を 3 カ月前に提供する早期警戒警報システムが開発されている。予測性能は過去の予測値と実測値との一致率が最低 60％を目標とする。	・終了時評価時点までに、プロジェクトは一定の長さのリードタイムをもつマラリア流行予測情報を実用に十分な精度で提供できる気候予測に基づいた流行予測モデル早期警戒警報システムの開発に成功した。 ・熱研による非線形統計モデルを基にしたマラリア流行予測モデルは、16 週間先まで予測された患者数と実際の患者数との相関係数は 0.7 以上を示し、特に直近 4 週間の相関は 0.8 かそれ以上を示した。 ・JAMSTEC による機械学習を基にしたマラリア流行予測モデルは、マラリア発生時期（9 月から翌 5 月まで）において、リンポポ州のすべての地区で高い予測精度（ROCAUC で 0.712）を示している。 ・UP による線形統計モデルを基にしたマラリア流行予測モデルは、マラリア流行シーズンの 1 カ月前（すなわち 11 月）に 12 月から翌年 2 月までの 3 カ月全体の予測を精度高く提供し、患者数の予測値と実測値の相関係数は 0.8 と非常に高い。 ・予測精度の高いモデルを用いて、3 カ月先まで月ごとにリンポポ州の各地区でマラリア流行発生確率を予測するアンサンブルモデルを作成することができた。 ・指標に設定されているように予測性能を予測値と実測値の一致率で表現することは難しいが、上述のような相関係数や ROCAUC スコアは一般的に 0.7 以上であれば高い性能であると理解できるため、プロジェクトで開発した非線形統計モデル及び機械学習を基にしたマラリア流行予測モデルは、実用レベルの性能を有していると評価できる。

1-2. 終了時評価時点までに、肺炎の季節変化を 3 カ月前に予測する早期警戒警報システムの開発可能性を示す。予測性能は過去の予測値と実測値との一致率が最低 60%とする。	・肺炎に関しては、患者数と相関が認められた気候変数が気温のみであり、さらに気温の日較差の予測を行うことは技術的に困難であることから、現時点では肺炎については気候に基づいた流行予測モデルの開発が困難であることが明らかとなった。
1-3. 評価時点までに、下痢症の季節変化を 3 カ月前に予測する早期警戒警報システムの開発可能性を示す。予測性能は過去の予測値と実測値との一致率が最低 60%とする。	・プロジェクトは下痢症件数と気候変数及び気候現象との間に有意な相関関係があることを確認した。流行予測モデルが完成次第、予測性能の検証、モデルの調整を実施する予定である。 ・ただし、終了時評価時点ではモデル開発の検討を開始した段階であり、2019 年 5 月のプロジェクト期間終了までにこれらの作業を完了することは困難である見込みである。 ・しかしながら、南アフリカ・日本国側双方の研究機関は設立予定である iDEWS 事務局の下で開発作業を継続する意思を表明している。
1-4. C/P 研究者である iDEWS、感染症数理・統計、短気気候変動予測システム、気候変動と感染症に関する学術論文が、ピアレビューのある国際専門誌にそれぞれ 4 報以上掲載されている。	・気候に関した論文 30 報、感染症流行予測に関した論文 10 報、健康学に関する論文 4 報が審査のある国際専門誌に発表されている。 ・現時点でも感染症流行予測に関する論文を複数件準備中である。

プロジェクトの前半までに、JAMSTEC は CSIR と協力しながら海氷を考慮した高解像度化した新型の大気–海洋結合モデルを用いた短期気候変動予測システム（SINTEX-F2）の開発に成功し、南部アフリカの気候予測の精度が大幅に向上した。これにより、リンポポ州のマラリア流行に影響を及ぼすモザンビークやジンバブエなどのマラリア高浸淫国の気候も高い精度で予測できるようになっている。また、SINTEX-F2 による地球規模季節予測情報の局地的高解像度化（ダウンスケーリング：約 $10km^2$ 程度）にも成功している。さらに、UP も独自のアンサンブル予測による気候変動予測システムを開発し、その後、予測のダウンスケーリングにも成功した。これらの研究成果はそれぞれ国際誌に論文として発表されている。これらの技術は以下に示す感染症流行予測モデルのすべてと組み合わせて活用されている。

マラリアについて、熱研及び JAMSTEC はそれぞれ非線形統計モデル及び機械学習を基にした流行予測モデルを開発し、指標 1−1 で示したとおり、実際のマラリア予防対策への適用に十分な流行予測精度（予測値と実測値の相関係数が 0.7 以上）を示している。後ろ向き検証ではあるが、約 20 年ぶりの大きなマラリア流行となった 2016～2017 年流行シーズンのマラリアの流行を予測できており、翌 2017～2018 年シーズンは同程度の流行規模となることを前向き予測で的中させている。なお、プロジェクトは今シーズン（2018～2019年）の予測も行ったが、終了時評価時点の 2019 年 1 月の患者数は予測値と近似している。

また、UP も十分に実用レベルの予測精度をもつ独自のアンサンブル気候変動予測システムに基づいたマラリア流行予測統計モデルを開発し、予測精度も実用レベルであることが確認されている。これと並行して、JAMSTEC 及び UWC はそれぞれ数理モデルを基にしたマラリア流行予測モデルの開発を行っている。終了時評価時点ではこれら 2 つのモデルは実用レベルに達していないが、プロジェクト期間終了後も引き続き、開発作業が継続されることが見込まれている。表－1 にプロジェクトがこれまで開発した気候変動予測を基にしたマラリア流行予測モデルの概要を示す。これらのモデルはそれぞれ異なる特徴を有し（予測のリードタイムや予測期間など）、これらを組み合わせて予測情報を作成することで、より事前対策等の計画が効果的、効率的に実施できる可能性がある。

表－１　プロジェクトが開発した気候予測に基づいた感染症流行予測モデルの特徴

開発者		気候予測モデル			感染症流行予測モデル		予測性能		
		地球規模気候予測モデル	方　法	ダウンスケーリング	原　理	方　法	リードタイム	予測範囲（期間）	実用性
日本	JAMSTEC /熱研	SINTEX-F2	108-メンバー・アンサンブル予測	成功	機械学習に基づくモデル	－	16 週	4 週	達成
	JAMSTEC /熱研	SINTEX-F2	108-メンバー・アンサンブル予測	成功	数理モデル	VECTRI モデル	試験中		未達成
	JAMSTEC /熱研	SINTEX-F2	108-メンバー・アンサンブル予測	成功	統計モデル	非線形モデル	12 週	1 週	達成
南アフリカ	プレトリア大学（UP）	北米マルチモデルアンサンブル	アンサンブル予測	成功	統計モデル	線型モデル	4 週	12 週	達成
	西ケープ大学（UWC）	SAWS 観測データ	試験中		数理モデル	コンバートメント・モデル	試験中		未達成

下痢症に対する気候予測に基づいた流行予測モデル開発は、プロジェクトの前半でのデータベース構築に想定以上の時間と労力を要し、終了時評価時点ではモデルの開発の検討が開始された段階である。しかしながら、プロジェクトは下痢症患者数が気候変数及び気候現象との間に高い相関性があることを明らかにした。これにより、気候予測に基づいた流行予測モデルを下痢症に適用できる可能性が確認された。2019 年 5 月までに実用レベルの予測性能を示すモデルの開発は困難である見込みだが、南アフリカ・日本国側双方の研究機関はプロジェクト期間終了後も開発作業を継続する意向を示している。他方、肺炎については患者数に季節性が確認されたものの、流行と相関性が確認できたのは気温のみであり、気候予測に基づいた流行予測モデルの開発を行うに十分な数の気候変数を得ることができず、現時点では肺炎についてはモデル開発を行うことは技術的に困難であることが確認された。しかしながら、さまざまな検証の結果として肺炎は気候予測に基づいた流行予測モデルの開発が技術的に困難であることを導き出したといえることから、このような経験は今後他の対象疾患への気候予測に基づいた流行予測モデル開発の適用を検討する際に重要なヒントとなると考えられ、実際の開発には至らなかったものの、双方の研究機関は重要な知見を得たと考えることができる。

なお、終了時評価時点でプロジェクトは合計 44 報の学術論文を発表している。そのう

ち 30 報は気象学関連の論文であり、短期気候変動予測システムの高精度化やダウンスケーリングなど直接的に本プロジェクトに関連する内容に加え、南部アフリカ地域の降水量が季節変動や年々変動だけではなく、10 年規模でゆっくり変動していることを明らかにするなど、学術的に興味深い発見も得られている。このように気候変動予測技術が確立した中間レビュー以降に気候変動予測を基にした感染症流行予測モデル開発にかかわる研究が本格化し、上述のとおり、マラリアに関しては終了時評価時点では実用レベルの予測性能を有するモデルが 3 種類完成したところであり、これまでに感染症を含む保健分野にかかわる学術論文は 14 報であるが、関連する研究成果は今後数多く報告されるものと見込まれる。

このように、マラリアについては気候予測に基づいた流行予測モデルは実用レベルの予測性能である。下痢症についてもモデル開発の見通しが得られ、開発作業は iDEWS 事務局の下で確実に継続されることになっていることから、プロジェクト終了後 2～3 年程度で開発作業が完了できる見込みである。肺炎についてはモデル開発が技術的に困難であることが明らかとなったが、今後の研究活動に重要な経験と知見を与えたといえる。また、プロジェクト全体で得られた研究成果は終了時評価時点で 44 報が国際誌に発表されていることから、成果 1 は技術協力の観点からはおおむねその目的を達成したと考えられる。

2） 成果 2

成果 2 の達成度を以下に示す。

【成果 2】 気候予測に基づいた感染性疾患流行早期警戒システム（iDEWS）の運用指針がリンポポ州で策定される。	
指　標	達成度
2-1. 中間レビューまでに、iDEWS 運用準備委員会が立ち上げられている。	・2017 年 1 月に正式に iDEWS 導入準備委員会が発足した。南アフリカ側の参画機関は、LDOH、NDOH、SAMRC、CSIR、SAWS、NICD 等であり、日本側研究者は、アドバイザーとして参加している。 ・終了時評価までに iDEWS 導入準備委員会を合計 4 回リンポポ州で開催し、提供基準の設定やマラリア流行予測情報伝達方法（アウトブレイク警報を含む）等のマラリア流行予測結果に基づく対策の試験実施方法等を検討した。
2-2. 2017 年 10 月までに、iDEWS 運用指針がリンポポ州の関係当局で検討されている。	・2017～2018 年のマラリア流行シーズンでの試験引用の結果から、予測情報を用いた対策の実施に効果的な運用方法を決定するには、更に数年の経験を積む必要があると判断された。 ・しかしながら、iDEWS 準備委員会メンバーも含めた関係機関はプロジェクトで開発した気候予測を基にしたマラリア流行予測情報は実際のマラリア予防対策への適用に十分な実用レベルに達していると評価し、終了時評価時点で具体的に iDEWS 事務局の設立に向けた取り組みを行っている。 ・iDEWS 事務局の下、十分な検討が行われたうえで、運用指針は確定される見込みである。

警戒情報の発令基準について、当初はマラリア・アウトブレイクの早期検出に基づく警戒情報の発令によるアウトブレイク発生予防や早期封じ込めのための対応実施を行うことを想定していたが、流行予測の特性やモザンビーク等のマラリア高侵淫国と比較すると患者数の少ないリンポポ州での運用を考慮した場合、個別のアウトブレイク警戒情報を発令するのではなく、原則的には定期的な流行予測情報を発表し、運用指針等に従った対応を行うことを関係者間で合意している。プロジェクトは非線形統計モデル及び機械学習に基づくマラリア流行予測モデルを開発したが、それぞれの予測性能にかかわる特徴を加味した警戒情報の構築が検討されている。

また、2017 年 1 月に発足した iDEWS 導入準備委員会は研究機関だけでなく、感染症流行予測情報の実際のユーザーであるLDOHや将来の制度化等をめざすうえで重要なNDOHや SAWS、NICD などの国レベルの機関が参加している。この準備委員会の下で実際にリンポポ州にてマラリア流行予測性能の検証や、予測結果に基づく対応（介入）など運用の検討がなされた。その結果、すべてのメンバー機関は気候予測に基づいた流行予測モデルの予測性能を実用レベルと評価し、iDEWS 事務局の設立に向けた関係機関間の合意に結びついた。上記の試験導入によって運用指針の策定には更に経験を積む必要性が確認されたため、プロジェクト期間内には完成できないが、検証作業は iDEWS 事務局の下で着実に実施される見込みである。

以上のことから、十分な経験と根拠に基づいた iDEWS 運用指針がプロジェクト期間終了後数年以内には着実に完成することが見込まれるため、成果 2 もその目的は満たされたと見なすことができる。

3) 成果 3

成果 3 の達成度を以下に示す。

【成果 3】 iDEWS の予測性能と運用性が実証される。	
指　標	達成度
3-1. 2018 年 5 月までに、iDEWS の予測性能と運用性がリンポポ州での導入試験により評価されている。	・2016～2017 年のマラリア流行シーズンの患者数の後ろ向き予測の成功を受け、リンポポ州政府の要請に基づいてプロジェクトは 2017～2018 年シーズンの前向き予測情報の提供を行った。予測情報を実際のマラリア予防対策に適用するにあたり、予測情報の伝達方法や共有範囲などの検討を行った。 ・予測情報に基づき LDOH は流行のホットスポットと予測された地域の追加的 IRS や住民に対する啓発活動を実施したところ、介入が報告患者数や死亡率の低下に影響した可能性を示唆する結果が得られた。しかしながら、介入効果を証明するためには、更なる科学的検証が必要である。
3-2. 2019 年 2 月までに、iDEWS の他州や隣国を含む他の地域での適用性がしかるべき関係当局に提示されている。	・2016～2017 年流行シーズン、2017～2018 流行シーズンでは、南アフリカに隣接する周辺国でも流行が発生しており、実際にマラリア患者数データの提供を受けているモザンビークに南アフリカで開発された予想システムを適用したところ、モザンビークでも十分な精度で予測できることが確認された。 この結果は iDEWS 導入準備委員会メンバーである NDOH や NICD など

	の国レベルの機関にも共有されており、個別の連絡やワークショップ、会議機会等を通じてモザンビーク当局にも共有されている。 ・また、南アフリカ全土のマラリア患者情報も iDEWS 専用のデータベースに蓄積されており、他の州への適応性も評価できる基盤ができている。さらに、"Elimination 8"を通じて南部アフリカ各国との協力が開始できれば、それぞれの国のマラリア流行データも収集、適用することで、気候予測に基づいた流行予測モデルを大きく展開できる可能性は高い。

上記のとおり、プロジェクトは流行予測モデルが 20 年ぶりの大きなマラリア流行が起こった 2016～2017 年流行シーズンのマラリア患者数を高い精度で予測できることを確認し、翌シーズンは予測情報を実際のリンポポ州でのマラリア予防対策へ適用した。その結果、介入によりマラリアによる死亡率が低下した可能性を示す結果が得られ、患者数も予測値よりも若干減少していた。しかしながら、予測情報に基づく介入の効果を証明するためには、隣国からのマラリアキャリアの流入などさまざまな要因を考慮してより正確な解析を行う必要がある。

以上の結果から、予測情報を用いた対策の実施に効果的な運用方法を決定するには、さらに数年の経験を積む必要があると判断された。しかしながら、iDEWS 準備委員会メンバーも含めた関係機関はプロジェクトで開発した気候予測を基にしたマラリア流行予測情報は、実際のマラリア予防対策への適用に十分な実用レベルに達していると評価し、終了時評価時点で具体的に iDEWS 事務局の設立に向けた取り組みを行っている。iDEWS 事務局の下、十分な検討が行われたうえで、運用指針は確定される見込みである。

下痢症についても流行と気候変数及び気候現象との間に相関性が確認され、終了時評価時点ではモデル化に向けた具体的な検討が開始された段階である。したがって、下痢症については予測性能と運用性の評価をプロジェクト期間内に実施することはできないが、こちらもモデルが完成次第、iDEWS 事務局の下で実施される見込みである。

以上のことから、マラリア及び下痢症については、モデルの予測性能、運用性が iDEWS 事務局の下で検証され、プロジェクト期間終了後数年以内には着実に完成することが見込まれるため、成果 3 もその目的はおおむね満たされたと見なすことができる。

(3) プロジェクト目標の達成度

【プロジェクト目標】
南部アフリカへの適用に向けた先駆けとして、感染症対策のための気候予測に基づいた早期警戒システムモデルが確立される。

指　標	達成度
1. プロジェクト期間終了までに、iDEWS、運用指針、運用コスト等が他の地域への展開に向けた先駆モデルとしてパッケージ化されている。	・プロジェクト終了後 2 年間は iDEWS 事務局を南アフリカ側実施機関によるジョイントベンチャーとして運営し、上記のようなエビデンスの構築や運用指針等の確定を行うことを計画している。その後、それら成果をもって南アフリカ政府機関と協議し、同事務局を南アフリカの公的機関に位置づけることをめざしている。 ・マラリアについては 2017～2018 年流行シーズンに予測情報に基づく予防対策を試験的に実施したが、予測情報をより効果的に活用するためには運用上の改善を継続的に実施する必要性が示唆された。したがって、

	プロジェクト期間終了後も引き続き iDEWS 事務局の下で運用指針の最適化が実施される見込みであり、最終化された段階で新規導入や通常運用のためのコスト分析、他の地域への展開に向けたパッケージ化が行われる見込みである。 ・下痢症についても流行予測モデルが完成次第、マラリアと同様の手順で運用やコスト分析、パッケージ化が iDEWS 事務局の下で実施される見込みである。
2. プロジェクト期間終了までに、iDEWS が（感染症対策の）ツールとして南アフリカの関係機関に提示されている。	・マラリアに関しては、iDEWS 導入準備委員会の構成メンバーに NDOH や NICD、LDOH など国レベル、現場レベルの行政機関も含まれており、これまでの活動を通じて予測性能や運用上の課題は共有されている。委員会のメンバーはプロジェクトで開発したマラリア予測モデルを高く評価しており、実際の感染症対策ツールとして活用するための取り組みを強化する見込みである。 ・また、同委員会には SAWS や ACCESS、CSIR など気象・気象にかかわる研究やサービスを担当する組織が含まれており、南アフリカ側は高精度化やダウンスケーリングが実現した気候予測情報の他分野（農業、災害対策など）への適用を念頭においており、iDEWS 事務局はその実施基盤として活用されることを期待している。

これまでの日本側研究機関、南アフリカの研究機関及び行政機関の努力により、南部アフリカ地域の短期気候変動予測システムは高精度化され、ダウンスケーリングも成功した。この結果を基に、プロジェクトは実用レベルの予測性能を有する 3 つのマラリア流行予測モデルを開発し、これらの予測情報に基づいた実際の予防対策が試験的に実施され、その効果や課題も確認されている。南アフリカ側研究機関、行政機関はこれまでの成果を高く評価し、iDEWS 事務局を設立し、気候変動予測を基にした、特にマラリアの感染症予測サービスを将来的に実際の行政サービスの一部とするための具体的な取り組みを開始している。さらに、終了時評価時点でプロジェクトの研究機関は気候学研究、感染症研究グループともモザンビークとの共同研究を開始しており、今後、モデルの予測性能は一層向上するものと考えられる。加えて、マラリアに関しては“Elimination 8”との協力も具体化しつつあり、南部アフリカ地域への展開も大いに期待できる。なお、下痢症については前半の活動の遅れもあってモデル化までは到達できていないが、iDEWS 事務局の下で開発作業は継続されることとなっている。肺炎については気候変動予測に基づく流行予測モデルの開発への適用が技術的に困難であることが確認されたが、その判断に至るまでの検討プロセスは、これから他の疾患への適用を検討する際の重要な基礎情報を与えたと考えられる。

これらの活動を通して気候予測、感染症流行予測とも多くの科学的知見や研究成果が得られ、特にプロジェクトの前半の活動の中心であった気候変動予測に関する研究から多くの学術論文が国際誌に発表されている。感染症流行予測モデルの開発や実際の予防対策への適用に関する知見や研究成果もプロジェクトの後半で創出されており、プロジェクト期間終了後も多くの学術論文として発表される見込みである。

他方、南アフリカ側研究機関は既に一定の研究能力を備えており、本プロジェクトでは他の開発途上国との共同研究のように日本側から「技術移転」を行うというよりは、イコールパートナーとして高いレベルで技術交流を行うことで､双方の研究能力が向上するとともに、

さまざまな研究分野、組織機能（研究、行政、サービスなど）を有するメンバーが連携するプラットフォームが形成されたことによって、今後も高いレベルでシナジー効果が得られるものと期待される。

このように、南部アフリカへの適用に向けた先駆けとして感染症対策のための気候予測に基づいた早期警戒システムモデルの確立（プロジェクト目標）は数年以内には着実に達成できる見込みである。また、上記のように学術的観点、ODA 技術協力の観点の両方で大きな成果が確認されており、現時点での課題も適切に整理されていることから、終了時評価時点で本プロジェクトはその目的をおおむね達成できたものと見なすことができる。

３－３　実施プロセスの検証

(1) プロジェクト管理と関係者間のコミュニケーション

実際の共同研究を行うために必要な南アフリカの研究機関が再検討され、プロジェクトが開始されてから中間レビューまでに NICD、SAWS、UP、UV がプロジェクトの実施機関に加えられ、南アフリカ国家災害管理センター（National Disaster Management Centre：NDMC）、九州大学が外部協力機関となった。これにより、本プロジェクトの実施機関は外部協力機関を含め南アフリカ側で 14 機関、日本側 3 機関の合計 17 機関となった。

これは他の感染症分野の SATREPS プロジェクトのなかでも圧倒的に参画機関数が多く、連絡調整の困難さがうかがえるが、特に気象学研究グループの多くは過去の SATREPS プロジェクトから協力関係が継続されており、感染症研究グループともプレトリアに駐在しているプロジェクト業務調整員（JICA 専門家）とリンポポ州に駐在していた日本人研究者（JICA 専門家）の丁寧な連絡調整管理により、プロジェクト期間を通して円滑なコミュニケーションが維持されている。また、南アフリカ側関係機関は研究機関や行政機関、気候分野、感染症分野、国レベル、現場レベルと非常に多岐にわたるが、ACCESS/CSIR のプロジェクト・マネジャーが非常によく取りまとめており、日本側との連絡調整もスムーズに行われた。JICA 南アフリカ事務所も積極的にプロジェクト運営管理を支援しており、総合的に、プロジェクト期間を通して適切なプロジェクト管理が継続されてきたと考えられる。

(2) オーナーシップ及び自立性

これまで示してきたとおり、南アフリカ側実施機関はプロジェクトの成果を非常に高く評価し、プロジェクト期間終了後は南アフリカ側が主体となって iDEWS 事務局を設立する計画である。iDEWS 事務局はプロジェクトの成果を実際の感染症対策に適用させるとともに、他の分野への応用や隣国への展開などを主体的に実施していくことが期待されており、終了時評価時点で設立や展開のための具体的な取り組みが開始されている。したがって、南アフリカ側のプロジェクトのオーナーシップ、自立性ともに非常に高いと考えられる。

(3) PDM のアップデート

プロジェクトデザイン時には、プロジェクトで開発する気候予測に基づいた感染症流行予測モデルの予測精度をどのようにして測定するか、目標とするレベル（目標値等）を指標としてどのように設定するかについては、具体的にモデルの開発作業を開始したうえで、実用

化を想定して南アフリカ側と協議のうえで決定することとなっていた。つまり、詳細計画策定調査で合意した PDM version 0 やプロジェクト開始時に開催された JCC で承認された PDM version 1（内容は version 0 と同じ）では、成果 1 の指標でマラリア、下痢症、肺炎に関する指標が未決定のままであった。

2016 年 10 月 4 日に開催された第 3 回 JCC でプロジェクト･チームより PDM version 1（2014 年 8 月 6 日）の修正が提案され、version 2 として承認された。

変更内容と変更後の指標の説明は以下のとおりである。

	変更前	変更後
成果1の指標	（1）終了時評価時点までに、XX のような予測性能を有するマラリア iDEWS が開発されている。	（1）終了時評価時点までに、マラリアのアウトブレイクの予測確率を 3 カ月前に提供する早期警戒警報システムが開発されている。予測性能は過去の予測値と実測値との一致率が最低 60%を目標とする。
	（2）終了時評価時点までに、YY のような予測性能を有する肺炎 iDEWS が開発されている。	（2）終了時評価時点までに、肺炎の季節変化を 3 カ月前に予測する早期警戒警報システムの開発可能性を示す。予測性能は過去の予測値と実測値との一致率が最低 60%とする。
	（3）終了時評価時点までに、ZZ のような予測性能を有する下痢症 iDEWS が開発されている。	（3）終了時評価時点までに、下痢症の季節変化を 3 カ月前に予測する早期警戒警報システムの開発可能性を示す。予測性能は過去の予測値と実測値との一致率が最低 60%とする。

第４章　評価結果

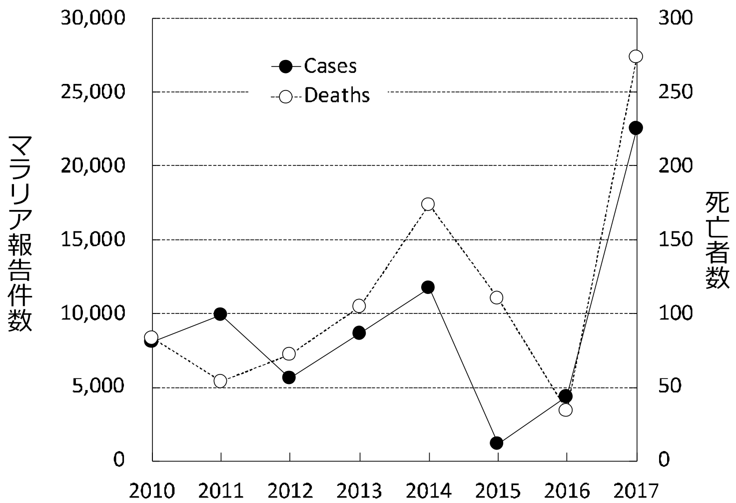
４－１　妥当性

プロジェクトの妥当性はこれまで高く維持されている。

(1) 南アフリカにおける保健政策・科学技術政策やターゲットグループのニーズとプロジェクト目標の一致性

南アフリカを含む南部アフリカ諸国では、感染症は依然として脅威である。南アフリカでは近年は感染症による死亡が減少傾向にあるものの、下痢症及び肺炎は依然として5歳未満児の死亡原因の上位を占める（それぞれ、8.7%、16.9%：2015年)[13]。

マラリアについては他の南部アフリカ諸国のなかでは比較的よく制御されているが、モザンビークやジンバブエなどのマラリア浸淫国に国境を接している南アフリカ北東部、特に本プロジェクトの対象地域であるリンポポ州は依然としてマラリア感染リスクにさらされている[14]。実際に、図－１に示すように、中間レビューが実施された2016年は報告数が4,323件、死亡者数が34件と排除に近いレベルと考えられていたが、2017年には報告数は前年の5倍以上の22,517件、死亡者数も274件と約8倍となった。翌2018年も同程度の大きな流行が起こっており、南アフリカは依然としてマラリアのリスクにさらされているといえる。



図－１　マラリア報告件数と死亡者数の推移

このような状況において南アフリカ保健省は「戦略計画 2015-2020」のなかで感染症対策の強化は国家プログラム「一次医療サービス」に位置づけられ、感染症サーベイランスシステムの強化や国際保健規則（International Health Regulation : IHR）に沿った公衆衛生上の緊急事態への備えと対応能力強化を推進するとしている。また、南アフリカ政府は日本との科学技術協力の実施を重視しており、2014年にDSTと在南アフリカ日本大使館が共同で発表した“South Africa-Japan Cooperation in Science and Technology”のなかでも南アフリカでの科学

[13] 2015年国連推計より引用（UNICEF. Under 5 mortality : Current Status and Progress. New York : UNICEF, 2017. *https://data.unicef.org/topic/child-survival/under-five-mortality/*）

[14] World Malaria Report 2018, WHO

技術協力における JICA の重要性や SATREPS の役割などが明記されるとともに、本プロジェクトの内容も紹介されている。

以上のことから、南アフリカ・日本国側双方の研究機関の技術力向上や根拠（研究成果や新規知見など)に基づいた感染症対策を行う本プロジェクトの目的と南アフリカの保健政策、科学技術政策並びにニーズとの一致性は更に高まったといえる。

(2) 日本の援助方針とプロジェクト目標の一致

わが国の ODA 方針においても感染症対策を重要視しており、2013 年 6 月の第 5 回アフリカ開発会議（TICAD V）で合意された「横浜宣言 2013」の具体的施策となる「横浜行動計画 2013-2017」でも感染症対策の重要性が改めて示されるとともに、気候変動に対する取り組みを多セクターで行うことの重要性も示されている。2016 年 8 月に実施された TICAD VI で採択された「ナイロビ宣言」では、「横浜宣言」及び「横浜行動計画」は 2019 年の次回 TICAD まで有効であることが確認されている。

また、TICAD VI に向けて外務大臣科学技術顧問によって作成された提言「科学技術・イノベーションの力でアフリカを豊かに」には、「人材育成を通じたアフリカの科学技術水準の向上」及び「研究開発の成果を社会全体へ還元」は、まさに SATREPS の理念と一致するものであることから、本プロジェクトはわが国の科学技術外交戦略に一致するものである。

したがって、気候変動予測に基づいた感染症早期警戒システムの確立をめざす本プロジェクトと、わが国の国際保健政策並びに科学技術外交戦略との一致性も高い。

(3) 気候変動予測に基づいた感染症対策に関する国際的要求について

WHO は地球温暖化などの気候変動が感染症など人の健康に対する影響について対策の必要性を明確に示している。特に“WHO Global Programme on Climate Change & Health”（2016）のなかで気候変動と健康に関する科学的根拠を得ることの重要性を示している。したがって、本プロジェクトを通じて気候変動とマラリア、肺炎、下痢症との相関関係や気候変動に基づいた感染症流行予測モデルの開発、予測情報に基づく行政的な対応などに関する科学的分析は、このような国際的要求にもかなうものと考えられる。

気候や気象に基づく感染症流行予測モデルの開発は学術的に多くの専門家により実施されているが、気候「予測」に基づいた感染症流行予測モデルの開発を行っている研究グループは他にほとんどなく、しかも実用レベルの予測性能を有する感染症流行予測モデルを複数開発した研究グループは、現時点では世界で本プロジェクト以外にはないといえる。これらのプロジェクトの研究成果は 2018 年 12 月に開催された世界的に権威のある米国地球物理学連合の秋季学会で発表され、非常に高い評価を得ている。本プロジェクトではマラリア流行予測情報の実際の予防対策への適用を可能にするために更なる継続的な検証が必要であるが、将来的に根拠に基づいた運用指針を確立することができれば、国際的に世界初の事例を提示することになる。

(4) 実施方法の適切性

1) 確定診断名でない「肺炎」及び「下痢症」を対象として iDEWS 開発に向けた研究活動を実施することの論理的根拠

「肺炎」は肺の炎症性疾患の 1 つの状態であり、原因は病原体の感染以外にも、薬剤性肺炎など感染以外の原因で発生する場合がある。同様に、「下痢症」も感染性、非感染性の原因で発生する。病原体もウイルスや細菌、真菌などさまざまな種類があり、それぞれの種類のなかでも、原因によっては予防対策や治療が異なる。つまり、肺炎や下痢を起こす原因は多種多様であり、発症にもさまざまな要因が影響することが考えられる。また、コレラ以外の下痢症は、マラリアのような災害レベルのアウトブレイクを起こすことはまれであり、通常の下痢症や肺炎は季節変動の範囲内で対応できる場合がほとんどである。このような条件下で、「果たして気候変動予測という限定的な要素が肺炎や下痢症の発生にどれだけ影響するのか」や「季節変動の範囲内での対応が主である疾患に対して、予測システムを用いた行政対応が必要なのか」などの疑問が日本側関係者内で惹起した。

特に南アフリカの地方部ではコレラ以外の下痢症や肺炎の原因について通常は確定診断を得ることが困難であるため、「肺炎」や「下痢症」という疾患群診断名である。しかしながら、これら疾患群と気候変数や気候現象との間に一定程度の相関関係が確認されたことから、マラリアに比較して圧倒的に患者数や死亡者数の多い肺炎、下痢症の患者数増加などの予測情報を保健局や医療施設が得ることは、都市部と比較して医療環境が劣る地方部では予防対策や備えを行ううえで重要であり、本プロジェクトで数カ月以上の予測期間で流行予測情報を得ることのニーズは非常に高いことが、LDOH などのリンポポ州の C/P だけでなく、南アフリカの研究者との面談調査を通じて確認された。

肺炎については技術的観点から気候予測に基づいた流行予測モデル開発の適用とならないことが明らかとなったが、下痢症については終了時評価時点でモデルの開発作業が開始された段階である。とはいえ、肺炎は原因によって予防対策や治療法は異なることに変わりがないため、運用規定の作成、特に関係者間で「肺炎」をどのように定義し、流行予測情報にしたがってどのような対応を行うかについては、プロジェクト期間終了後も引き続き iDEWS 事務局の下で利用可能なエビデンスに基づき、リンポポ州の医療環境だけでなく、予算計画や物品の調達などさまざまな要因を十分考慮しながら慎重に決定されることが肝要である。

2） 南部アフリカ地域を対象とした気候予測に基づいた感染症流行予測モデルの開発を行ううえで南アフリカを技術協力の C/P 及び対象サイトとして選定したことの論理的根拠

さらに、本プロジェクトでは南アフリカで開発した技術もしくは技術に基づく感染症対策を、将来的に南部アフリカ地域に展開することを当初から念頭におき実施しているが、気候予測モデルや感染症流行予測モデルの開発を協力して実施するための研究基盤は南アフリカにおいて他にはなく、南アフリカをパートナー及び対象国としたことの妥当性も担保されている。

3） ジェンダーや民族、社会的階層、環境等に対する配慮

本プロジェクトはマラリア、下痢症、肺炎の流行予測に基づいた警戒システムの開発を行うものである。直接的に感染性物質等を取り扱うことはないため、環境や専門家（研究者）の健康被害等に対する特別な配慮は要しない。

他方、南アフリカの研究機関の技術力は比較的高いが、地方の大学等では学生が先端的な研究にふれる機会は限定的である。プロジェクトでは修士課程の学生を対象にレクチャーシリーズを実施したが、開催場所はプロジェクトサイトであるリンポポ州とし、リンポ

ポ大学（UL）やジンバブエ国境付近のヴェンダ大学（UV）の学生が参加できるよう配慮した。

４－２　有効性

プロジェクトの有効性は高い。

(1) プロジェクト目標の達成見込み

「３－２（3）プロジェクト目標の達成度」で示したとおり、プロジェクトの前半でJAMSTEC は短期気候変動予測システムの高精度化とダウンスケーリングに成功した。現時点で南部アフリカ地域では世界で最も精度の高い予測システムが開発されたといえる。また、南アフリカから東北方向に離れるにつれて気候に対する南極の海氷の影響が減少することから、ケニア周辺までは現行システムを用いて高い精度の気候予測が一定のリードタイムで提供することが技術的に可能な状態に達している。また、南アフリカ側もプレトリア大学（UP）が独自のアンサンブル気候予測モデルを開発し、こちらも実用レベルに達していると見込まれている。

中間レビュー以降は、マラリア、下痢症、肺炎を対象とした感染症流行予測モデルの開発を南アフリカ・日本国側双方の研究グループが実施し、最終的には気候予測モデルと連結させることで、気候予測モデルを基にした感染症流行予測モデルの開発を行った。

マラリアに関しては、日本側では SINTEX-F2 による気候予測を基礎として、JAMSTEC が機械学習を基にした流行予測モデルを、熱研では非線形統計モデルを基にしたモデルを完成させた。UP も独自のアンサンブル気候予測を基にした線形統計モデルによるマラリア流行予測モデルを終了時評価時点で完成させている。いずれのモデルも実用レベルの高い予測性能を示していることが確認されている。2017 年に開発作業がおおむね完了していた熱研による非線形統計モデル、JAMSTEC による機械学習を基にしたモデルは、リンポポ州政府の依頼によって 2017～2018 年マラリア流行シーズンの予流行測情報を提供し、予測情報に基づく予防対策の試験実施が行われた。プロジェクトからは予防対策のための介入がマラリアによる死亡者数の減少に一定程度の貢献があった可能性を示唆する結果が得られ、報告患者数も予測値よりも若干減少していた。しかしながら、これらの結果を正確に理解するには科学的な検証が必要であり、予測情報を最大限に活用するための予防対策介入方法を最適化するには 1 年程度の試験実施では困難であり、プロジェクト期間終了後も数年は検証結果に基づいた介入の試験実施を繰り返すことで運用指針を最終化できるものと考えられる。なお、運用指針の最適化を実現するには、単に予測情報に基づく介入効果のみを検討するのではなく、リンポポ州など対象地域の感染症対策にかかわるリソース（人材、予算など）や規制等を考慮に入れて検討されたい。したがって、必要によっては、iDEWS 事務局メンバーは公衆衛生学的研究の知見・経験のある人材や研究グループとの協同研究、実務協力の可能性を検討することが望ましい。

他方、下痢症と肺炎については紙ベースの病院データのデータベース化に想定以上の時間と労力を要し、その後の研究活動の進捗もその分の影響を受けた。下痢症に関して、プロジェクトは利用可能なデータの解析からその流行に対する気温と降水量の役割に関する強力なエビデンスを見出した。下痢症は特に降水量と気温の変動、具体的には冬期に干魃に向かう

と下痢症が増加する傾向が観察されている。また、エルニーニョ現象（通常より乾燥、気温が高くなる）の発生との強い相関も確認されたことから、下痢症に対して気候予測に基づいた流行予測モデル開発を行う理論的根拠は得られたと見なすことができる。さらに、下痢症については開発したモデルは下痢症の流行がある地域、つまり南アフリカ全土に適用可能である。下痢症は必ずしも病院で確定診断されないことから、プロジェクトでは患者数推定に治療薬販売や保険申請情報を代用情報として使用しているが、このアプローチは新規性があり、特に確定診断情報の入手に制限がある場合などは有効な手段と考えられる。このような研究成果はプロジェクトの重要な達成事項の 1 つであると見なすことができるが、このような情報を基にした対策の実用化については更に検討を深める必要があり、プロジェクト関係機関は iDEWS 事務局の下で継続的な開発作業を継続する意向を示している。

肺炎については患者数に季節性が確認されたものの、流行と相関性が確認できたのは気温（特に日較差）のみであり、気候予測に基づいた流行予測モデルの開発を行うに十分な数の気候変数を得ることができず、現時点では肺炎についてはモデル開発を行うことは技術的に困難であることが確認された。しかしながら、さまざまな検証の結果として肺炎は気候予測に基づいた流行予測モデルの開発が技術的に困難であることを導き出したといえることから、このような経験は今後他の対象疾患への気候予測に基づいた流行予測モデル開発の適用を検討する際に重要なヒントとなると考えられ、実際の開発には至らなかったものの、双方の研究機関は重要な知見を得たと考えることができる。

また、「３－２（2）成果の達成　1）成果 1」で示したとおり、これまでは短期気候変動予測システムの開発・改良とダウンスケーリングを中心とした気候学的研究に関する学術論文が終了時評価時点で数多く第一線の査読のある国際誌に発表されている。気候予測を基にした感染症流行予測モデル等に関する研究成果はこれまでに数報程度であるが、終了時評価時点ではさまざまな特徴を有する 3 つのマラリアの流行予測モデルが開発され、いずれも実用レベルであることが確認されている。今後はこれらモデルによる予測情報の実際のマラリア予防対策への適用が科学的視点をもって実施、効果検証が行われる予定であることから、今後関連する研究成果がプロジェクト期間終了後も数多く国際誌等に発表されることが見込まれる。他方、本プロジェクトは他の開発途上国との国際共同研究とは異なり、イコールパートナーとして非常に高いレベルで技術協力、技術交流が継続され、双方、気候変動に基づく感染症流行予測モデルの開発や、実際の予防対策への適用など未知の領域に挑み、プロジェクト開始前はまったくなにも実績がないところから、終了時評価時点では研究成果の社会実装が大いに期待できるまでの成果を得ている。このことは南アフリカ・日本国側双方の研究機関、行政機関、保健機関など関係機関が大きく能力を向上させたと考えられ、本プロジェクトは ODA の視点でも大きな成果を上げたと考えることができる。

このように、これまでに多くの研究成果が得られ、研究機関の組織機能強化、人材育成も達成していると考えられることから、終了時評価時点でのプロジェクトの有効性は、特に学術的側面で非常に高いと考えられる。

計画した 3 つの対象疾患に対して iDEWS を構築できてはいないものの、学術的にも ODA 技術支援の観点でも本プロジェクトの達成度は非常に高いと考えられ、本プロジェクトの有効性はおおむね高いと認められた。

(2) 成果及びプロジェクト目標達成のための外部条件

成果達成のための外部条件「プロジェクトの外部協力機関（DOH、SAWS、ARC、公共建物管理者等）から、プロジェクト活動の実施に必要な協力が得られる」の現状

気象の地上観測データは ARC 及び SAWS により提供されることを想定していたが、ARC からデータ提供の協力は得られなかった。SAWS についてはデータ提供に必要な契約に想定以上の時間がかかったが、2016 年 8 月に契約が締結され、データ入手が可能な状況となっている。なお、地上観測データはダウンスケーリングされた気候予測の予測精度検証に使用されたため、この遅延が SINTEX-F2 開発そのものには影響していない。

なお、SAWS 及び NICD はプロジェクト開始当初は外部協力機関だったが、研究成果の社会実装や持続性強化に向けた実施体制の強化との観点から、2015 年 10 月の第 2 回 JCC でプロジェクトの実施機関となることが承認された。

(3) 有効性への促進要因

本プロジェクトには実施機関だけで非常に多くの機関が参加しているが、気候変動予測モデル開発にかかわる研究グループ、感染症流行予測モデル開発にかかわる研究グループともに、email や電話などを通して頻繁に連絡、協議等が行われている。このことによって遠く離れた南アフリカと日本で共同研究が順調に実施され、上述したような研究成果が得られた。また、プロジェクトは協力期間の前半に気候予測、感染症対策にかかわる国レベルの機関を戦略的にメンバーとしたことによって､将来の社会実装に向けた実施体制の強化が図られた。これらのことは、プロジェクトの有効性を高めたと考えられる。

(4) 有効性に対する阻害要因

病院入院情報の電子化とデータベース化については、南アフリカ側の投入で実施されることで合意していた。紙ベースの入院情報約 28,000 件を電子化し、更にデータベース化するためには相当な労力が必要であり、そのための外注費の分配が必要だったが、南アフリカ側でそのための予算が使用できるようになるまでには予想以上の時間を要した。

このことにより、肺炎及び下痢症の感染症流行予測モデルの開発作業が大きく遅延した。結果として、気候予測を基にした流行予測モデルは技術的観点から肺炎には適用が困難であることが明らかになったが、下痢症についてはこの遅延が影響し、終了時評価時点ではようやくモデルの開発作業の検討が開始された段階である。本件は有効性に対する阻害要因と整理できる。

(5) その他

プロジェクト開始後、NDOH、LDOH 及び CSIR のプロジェクト・メンバーが異動となり、プロジェクトを離れた。それに伴い、新たなメンバーに対して協力関係を構築するために日本側プロジェクト・メンバーは一定の努力と時間を要した。また、プロジェクトの研究活動に参加していた南アフリカの若手研究者数名に入れ替えがあったが、プロジェクト・メンバーの努力によってプロジェクト活動実施に対する負の影響は回避されている。

４－３　効率性

以下に示す理由により、プロジェクトの効率性は中程度である。

(1) プロジェクト活動の進捗管理

本プロジェクトは、2014 年 5 月に行われた南アフリカ総選挙の影響により、MOU 署名に想定よりも時間を要し、南アフリカ（リンポポ州及びプレトリア）に駐在する 2 名の長期専門家（それぞれ研究者、業務調整員）の着任が同年 10 月となったため、研究機器の導入等に若干の遅延が生じた。しかしながら、南アフリカ・日本国側双方の研究機関が個別に実施する気候予測モデル開発・改良等は、専門家が着任する前からデータ解析や気候分析を行っていたため、プロジェクト開始後ただちに本格的に開始することができた。また、南アフリカ側研究機関間の共同研究実施のための MOU 締結に想定以上の時間を要し、気象地上観測データの入手などに遅延が生じた。

また、「４－２　有効性」でもふれたが、南アフリカ側の病院入院データのデータベース化のための予算が利用できるようになるのが 2016 年に入ってからとなったため、下痢症の流行予測モデル開発におおむね半年～1 年程度の遅延が生じ、結果的に終了時評価時点で完成することができなかった。

しかしながら、プロジェクト運営としては終了時評価までに実施された JCC に加え、南アフリカ･日本国側双方で実施されたシンポジウムの機会及び日常的な email や電話会議等で、研究の進捗や成果創出状況の管理はおおむね適切に実施されてきたと考えられる。このことは、「４－２　有効性」で示したとおり、プロジェクト活動としては半年～1 年程度の遅延が認められながらも、終了時評価時点で多くの研究成果を創出していることで説明できる。遅延の原因はプロジェクト外部の要因であったが、特に南アフリカ側 C/P は活動予算確保や iDEWS 組織化に最大限の努力を行っており、プロジェクト管理自体はプロジェクト期間を通して適切に実施されたと考えられる。

(2) 提供された機器及び材料の有効利用

南アフリカ側の既存の研究機器を最大限に活用して研究活動が実施されており、本プロジェクトでの研究機器等の導入はそれほど多くないが、中間レビューまでに、予定された研究機器の整備導入はおおむね終了した。

使用目的や環境によって使用頻度に差はあるが、導入された研究機器等はプロジェクトの活動のために使用されており、維持管理も適切に実施されていることが確認されている。

(3) 本邦研修で獲得した知識・技能の有効利用

これまでに 7 名の南アフリカ若手研究者が日本の研究機関で短期の研修を受講し（延べ 416 日間）、気候予測モデル開発や気候−感染症相関解析、感染症流行予測モデル開発などを学んだ。獲得した知識や技術はデータ収集作業や分析などを含むプロジェクトの研究活動に直接的・間接的に活用された。

特に気候変動予測グループからの研究者は、SINTEX-F2 からの気候予測情報の感染症流行予測への応用技術、及びダウンスケーリング技術を習得した。

(4) 外部リソースとの連携

1) 最新のマラリア流行予測数理モデル（VECTRI モデル）の共同開発

日本側研究機関は VECTRI モデルの情報（ソースコード）を開発者（イタリア人研究者）より提供を受け、共同で改良を行っている。本モデルは蚊の生態も考慮に入れて予測を行うものであり、本プロジェクトで開発したマラリア流行予測モデルのなかでも最も有力なモデルの 1 つとして認識されていた。しかしながら、VECTRI モデルを基にしたモデルは現時点では実用レベルの予測性能を得られておらず、プロジェクトは JAMSTEC を中心として協力期間終了後も引き続き改良を行う予定である。

2) マラリアサーベイランスシステム向上に向けた現地 NGO との連携

マラリア流行予測モデルの予測スキル検証やマラリア iDEWS の効果的な運用には、元情報となるサーベイランスシステムが適切に機能することが必要である。リンポポ州のマラリアサーベイランスシステム向上に向けて、プロジェクトは当初、熱研がケニアで実施している SATREPS プロジェクトで確立した携帯電話を用いた感染症報告システムをリンポポ州に適用することを検討しており、リンポポ州で開催されたシンポジウムでも同プロジェクトの専門家を招へいし講演を実施した。

しかしながら、その後、同州でクリントン財団の支援を受けた現地 NGO が同様のシステムを用いた報告システム向上のための支援を開始したため、本プロジェクトでは活動の重複回避、活動の効率化を念頭にケニアのシステムの導入は行わず、現地 NGO と協力、側面支援して現地マラリア報告システムの向上を行うこととした。上記した報告システムによって、中間レビューまでにマラリア患者発生情報は 24 時間以内に TMI にも報告されるようになった。TMI は報告に基づき、ただちに周辺住民に対する非症候性マラリアの調査を実施できるようになった。

(5) 効率性に対する促進要因

これまで示してきたとおり、本プロジェクトに実施機関として参加している南アフリカ側研究機関は 15 機関である。これらの機関はプレトリア、リンポポ、ダーバン、ケープタウンなど南アフリカの広範囲に点在している。

このような環境でありながらも、南アフリカに駐在している JICA 専門家（業務調整：初代と後任とも）と南アフリカ側プロジェクト・マネジャーは、相互に協力しながら南アフリカ・日本間だけでなく、南アフリカ内の実施機関間の連絡調整を綿密に実施しており、双方の研究機関による信頼も厚く、円滑な共同研究の運営管理に大きく貢献していると考えられる。

(6) 効率性に対する阻害要因

中間レビュー時には、予測情報に基づいたマラリア流行の予防対策実施を効果的かつ効率的に実施するために関連する専門性を有する JICA 専門家の投入を提言したが、実現しなかった。そのため、2017～2018 年マラリア流行シーズンの予測情報に基づいた試験的予防対策の実施は、十分な根拠や検討に基づいた介入とはならなかった可能性がある。

提言に基づいた効果的な投入が実現しなかったことにはさまざまな要因が考えられるものの、本件は効果的な投入による活動成果の最大化が一定程度阻害されたとも考えられるた

め、効率性の阻害要因と考えることができる。

４－４　インパクト

プロジェクトの実施によって、以下に示す正のインパクトが確認または期待されている。

(1) 想定される上位目標達成の可能性

SATREPS では上位目標の設定は必ずしも必要とされていない。しかしながら、SATREPS は研究成果の社会実装を強く意識した事業であり、プロジェクト目標にも「南部アフリカへの適用に向けた先駆けとして」と、感染症対策のための気候予測に基づいた早期警戒システムモデルがプロジェクト期間終了後に南アフリカの自助努力によって他地域に適用されることを念頭においている。

南アフリカのマラリアの多くはモザンビークやジンバブエの国境付近で発生していることから、プロジェクトの対象サイトをリンポポ州としている。これまでの研究により、リンポポ州でのマラリア患者数はモザンビーク南部及びジンバブエ南部の降水量と 3 カ月のラグで正の相関があることが明らかとなった。また、リンポポ州でのマラリア患者には一定の割合で隣国からの流入があることも示唆されており、マラリア流行予測モデルの予測スキル向上にはモザンビークなど隣国の情報も解析できることが望ましい。そのような観点からプロジェクトは既にモザンビーク保健省や同国マラリア対策プログラム担当官と協力を開始しており、同国の過去 20 年分のマラリア流行に関するデータの提供を受けている。プロジェクトで改良を行った気候予測モデルは既にモザンビークの気候予測が可能であり、プロジェクトで開発した現在のマラリア流行予測モデルを用いてモザンビークの流行予測を行うことは技術的に可能である。さらに、研究面での協力が得られれば媒介蚊の密度の高いモザンビークで媒介蚊の生態因子と流行の相関分析が可能となり、モデルの予測精度の更なる向上も見込まれる。

他方、SADC の下でマラリア排除に向けて南部アフリカ 8 カ国によって 2007 年に設立された“Elimination 8”は気候予測に基づくマラリア流行予測のメンバー国での適用に大きな関心を示しており、終了時評価時点では具体的な協力の方法等に関する協議が開始されている。“Elimination 8”を通じて南部アフリカ各国との協力が開始できれば、それぞれの国のマラリア流行データも収集、検証することで、気候予測に基づいた流行予測モデルを大きく展開できる可能性は高いと考えられる。

しかしながら、南アフリカの他州や隣国への適用を実現するには、マラリア流行予測情報に基づいた予防対策に対するひとつひとつの介入の効果についてエビデンスを構築し、そのエビデンスを基に現場の利用可能なリソース（人材、予算等）を考慮しながら、最終的には運用指針の最適化を行うことが求められる。さらには、その最適化された運用指針に則った予測情報に基づいた予防対策が、どれだけ患者数や死亡者数に影響を及ぼしたかについて科学的に検証し、包括的なエビデンスを構築することが必要である。これが実現できて初めて他の地域や近隣国への展開が行えるようになると考えられる。

(2) その他の正のインパクト

1)　南部アフリカの降水量の 10 年規模変動とマラリア患者数の関連性の発見

活動 1-2-3 で示したとおり、JAMSTEC は気候観測データの解析から、南部アフリカ地域の降水量が季節変動や年々変動だけではなく、10 年規模でゆっくり変動していることを明らかにした。また、SINTEX-F2 を用いた解析により、この 10 年規模の変動は南太平洋から南インド洋に東進する海面気圧と海面水温の 10 年規模変動と強く相関していることが明らかとなった。

この発見を基に、プロジェクトは南部アフリカ地域での 10 年規模の気候変動とリンポポ州のマラリア患者発生件数との正の相関関係について終了時評価時点で過去のデータを用いて詳細な解析を実施中である。これが証明できれば、南部アフリカで気候変動に基づく感染症流行予測モデル開発や具体的な行政的予防対策に大きな正のインパクトをもたらすと考えられる。

2) ザニンマラリア研究所（TMI）の機能強化

TMI に JICA 専門家（疫学・医用昆虫学）1 名が駐在し、長期にわたる共同の日常業務や研究活動を通じて、マラリア媒介蚊の研究を行うための施設設備の強化や研究技術移転がなされ、同所の機能強化、スタッフの能力強化が図られている。

具体的には、プロジェクトの実施によってグレーター・ギアニ地区をセンチネル・サイトとした成虫のマラリア媒介蚊サーベイランスシステムが確立した。同地区では蚊の採取やトラップの保守点検は同地の住民をアルバイト雇用して実施しているが、プロジェクト期間終了後も TMI によって維持されることが見込まれている。また、マラリア媒介蚊の幼虫サーベイランスは通常業務として実施されていたが、具体的な実施方法の改善や実施マニュアル、記録様式、標準操作手順書（SOP）などの作成、改訂が実施された。さらに、人のマラリアサーベイランスについても、TMI は初発症例（Index Cases）周辺の住民に対する能動的サーベイランス（非症候性マラリア感染の調査）の実施を通して、同専門家の支援により、調査実施の SOP や記録様式の作成、改善を行った。

3) iDEWS 開発をプラットフォームとした分野横断的関係者間連携

iDEWS の開発では、南アフリカと日本の研究機関の国際共同研究によって、気候予測を基にした感染症流行予測のモデル開発を学術的に行い、それを現場レベルの感染症予防対策に適用し、最終的には 1 つの感染症予防対策の実施システムとして確立することを目的としている。つまり、南アフリカと日本、気候学研究と感染症研究、研究機関と行政機関、国レベルと地方レベル、など、さまざまなプレーヤーが iDEWS 開発をプラットフォームとして有機的に連携してプロジェクト（研究）活動が継続されてきた。各メンバー機関はそれぞれの役割を適切に認識し、効果的なプロジェクトの連絡調整の下で多専門的アプローチが実現した。

近年は健康にかかわる課題解決に分野横断的研究協力の実施が推奨されているが、医学の中の多分野連携が行われることはあるが、まったく異なる学術分野が効果的に連結される事例は必ずしも多くない。さらに、研究機関と行政機関、国レベルと地方レベルなど多様な組織が効果的に連携できたことは、研究成果の社会実装を実現するためには非常に効果的であり、本プロジェクトは画期的な事例として認識することができる。

南アフリカ側実施機関はこの実現のためにプロジェクト期間終了後は iDEWS 事務局を設立し、取り組みを継続、発展させる意向を表明しており、将来的には iDEWS 事務局を行政機関の一部として位置づけることをめざすとともに、iDEWS 事務局をプラットフォー

ムとして更に農業や防災などの多分野との連携へと発展させることをめざしている。これが実現できれば、より多くの正のインパクトが創出されることが期待される。

(3) 負のインパクト

本プロジェクトの実施に起因する負のインパクトは、終了時評価時点において確認されていない。

４－５　持続性

プロジェクトによって生み出された便益の自立発展、自己展開は終了時評価時点においても一定程度見込まれる。

(1) 政策的、制度的側面

「４－１　妥当性」でも述べたとおり、南アフリカにおいて気候変動予測モデルや感染症流行予測モデル開発の技術力を高めながら、関連した研究成果に基づいた（根拠に基づく）感染症対策を行うことの政策的重要性はプロジェクト期間終了までのみならず、終了以降も継続することが強く見込まれるため、本プロジェクトの政策的持続性は終了時評価時点においても一定程度期待できる。このことは、NICD や SAWS などの国家機関がまもなく設立予定の iDEWS 事務局をリードすることが合意されていることでも説明できる。

また、iDEWS 準備委員会メンバーも含めた関係機関はプロジェクトで開発した気候予測を基にしたマラリア流行予測情報は実際のマラリア予防対策への適用に十分な実用レベルに達していると評価し、終了時評価時点で具体的に iDEWS 事務局の設立に向けた取り組みを行っている。当面はプロジェクト終了後 2 年間で運用指針の最適化を行い、iDEWS のマラリア予防対策に対する効果に関するエビデンスを構築する予定である。その後は構築したエビデンスを関係当局に提示し、最終的には iDEWS 事務局を行政機関の一部とすることをめざしている。気候予測や感染症対策の国レベルの関係当局である SAWS 及び NICD は同事務局のメンバーであることから、両組織を含む国レベルの関係当局や法律顧問等のコンサルテーションを受けながら、着実に iDEWS 事務局の行政組織化や iDEWS の公的利用に向けた政策・制度の側面からの取り組みが強化されることが望ましい。

(2) 財政的側面

プロジェクトの研究活動は、日本も含めて一般的には組織独自の研究予算のみで実施することは不可能で、競争的研究資金など外部組織からの支援を獲得するための継続的な努力を行う必要がある。そのため、終了時評価時点で研究継続のための財政的持続性を評価することは困難である。しかしながら、南アフリカ・日本国側双方の研究機関の研究能力は高く、本プロジェクトによって実用化に近いレベルに達した気候予測に基づいた感染症流行予測モデル開発や、予測情報に基づく介入等にかかわる研究はおそらく世界をリードしていると考えられることから、それぞれの機関がこの分野で外部の競争的研究資金等を獲得できる能力は高いと考えられる。

他方、上述のとおり iDEWS が南アフリカの感染症対策システムの一部となれば、行政システムとして継続運営のための予算は担保されることが見込まれる。また、プロジェクトは

iDEWS が将来的には南アフリカの他州や隣国で適用されることを念頭においていることから、予測モデルに加えて運用指針、新規導入や運用コスト分析なども含めたパッケージ化に向けた取り組みが iDEWS 事務局の下で継続的に実施されることが望ましい。

(3) 技術的側面

上述のとおり、南アフリカ・日本国側双方の研究機関の能力は高く、プロジェクト期間終了後もプロジェクトで獲得した新規の研究能力は更に向上することが強く見込まれる。なお、熱研、JAMSTEC はプロジェクト期間終了後も南アフリカ側プロジェクトメンバー機関との共同研究、協力活動を継続する意向を示しており、iDEWS 事務局に対しても何らかのかたちで参加もしくは協力することになっている。また、プロジェクトでは 3 つの異なる予測性能特性を有する気候予測に基づくマラリア流行予測モデル（JAMSTEC による機械学習を基にしたモデル、熱研による非線形統計モデル、UP による線形統計モデル）が実用レベルに達している。これと並行して、JAMSTEC 及び UWC は数理モデル（それぞれ、VECTRI モデル、コンパートメント・モデル）を基にしたマラリア流行予測モデルの開発を行っている。終了時評価時点ではこれら 2 つのモデルは実用レベルに達していないが、数理モデルを基にした感染症流行予測モデルは他の地域への高い適用性が期待できることから、プロジェクト期間終了後も引き続き開発作業が継続されることが見込まれている。

また、上述のとおり、本プロジェクトでは根拠に基づく感染症対策として現時点ではマラリア及び下痢症に対する iDEWS の確立をめざしている。また、プロジェクトは iDEWS を将来的には他州や隣国への展開も視野に入れた活動を行っており、そのためには感染症流行予測に基づく予防対策介入の効果に関するさまざまなエビデンスを蓄積し、それらを基に利用できる人材や予算などのリソースを考慮したその運用指針を最適化させ、最終的には iDEWS がリンポポ州で感染症予防対策メカニズムの一部として機能することを証明する必要がある。しかしながら、感染症流行予測情報に基づく感染症予防対策の実施は世界で初めての試みであり、そのような経験を有する専門家は存在しない。今後は iDEWS 事務局の下で継続的に介入効果のエビデンス構築や運用指針の最適化を検討する予定であることから、必要によっては感染症サーベイランス・レスポンスや公衆衛生学的研究の専門性のある外部の研究者もしくは実務者等の協力を得ることも検討する必要があると考えられる。

４－６　結論

本プロジェクトでは、JAMSTEC の開発した SINTEX-F2 と CSIR が開発した可変解像度地球システムモデルによる地球規模気候予測システムの精度の向上を図り、かつ予測のダウンスケーリングにも成功した。これにより、特に南部アフリカ地域の気候を高解像度で予測することを可能にした。また、プロジェクトは、改善された気候予測モデルを活用することで、特にマラリアについて 3 つの流行予測モデルの開発に成功した。これら 3 つのモデルはそれぞれ異なる特徴を有し、シーズンごとのマラリア・アウトブレイクを異なる時間スケールと予測基準、相互情報交換性を伴って、高精度での流行予測を行い、事前の対策の準備を可能にするレベルに達している。プロジェクトは、実際に 2017～2018 年シーズンのマラリアのアウトブレイク予測を提供し、その情報に基づき時宜を得た対策を行うことができた。しかしながら、介入効果を明らかにするためには、その科学的エビデンスを明らかにすることが必要である。今後は、南アフリカ側が中心と

なって設立される iDEWS 事務局によって、エビデンスの構築やそれに基づく運用指針の最適化（予測情報に基づく予防対策の実施を含む）の実施が期待される。加えて、iDEWS 事務局は、本プロジェクトの成果を南アフリカ国内の高浸淫地域だけでなく、マラリアの流行する近隣国へも展開することが期待されている。さらには、予測モデルの更なる改善を行いながら気候予測モデルの他地域及び他分野への適用､例えば農業や防災分野などへの応用も期待される｡このように、気候予測情報が他分野に適用されれば、プロジェクトの成果が大きな正のインパクトを創出する可能性が期待できる。

他方、本プロジェクトの下、協同研究を通して双方の研究機関の能力強化も図られ、これまでに共同研究成果が数多く国際誌に発表されている。プロジェクト終了後も、特に気候予測に基づくマラリア流行予測モデルの更新や気候予測情報に基づく対策の効果などにかかわる研究成果が継続して創出され、関連する学術論文も今後更に数多く発表されることが見込まれる。

以上の結果から、プロジェクトへの効果的な人材投入や想定外の活動遅延などにより「効率性」は中程度であったが､「妥当性」「有効性」「持続性」は高いと評価された。また、終了時評価時点でも本プロジェクトの研究成果の社会実装が具体的に見込まれることから、将来的な正のインパクトも大いに期待できる。これらを総合すると、学術的にも ODA 技術協力としても本プロジェクトの達成度は非常に高いと評価できる。

終了時評価チームは、これまでの成果をプロジェクト期間終了後も維持、更に発展させるために、各関係機関に対して以下の 4 点を提言する。

第５章　提言と教訓

５－１　提言

終了時評価の結果に基づき、終了時評価チームは以下のとおり提言する。

（1）iDEWS 事務局の設立と発展

南アフリカ側関係機関は、2018 年 12 月に設立宣言された iDEWS 事務局の役割と機能の明確化を図り、プロジェクト期間が終了する2019年5月までに実際の活動を開始していること。

（2）マラリア流行予測情報に基づいたマラリア予防対策の有効性の実証

プロジェクト期間終了後もマラリア流行予測情報に基づいた予防・診断・治療面における介入効果のエビデンスを構築すること。エビデンスに基づいたマラリア対策の運用指針の最適化を図ること、及び得られたエビデンスや経験をグローバルなアクティビティへと昇華させるために WHO 等への情報提供を行うことを期待する。

（3）周辺国への経験の共有

iDEWS 事務局が、プロジェクトで開発された成果をリンポポ州と国境を接するモザンビークをはじめ“Elimination 8”メンバー国に共有する体制を整えていくこと。また、iDEWS 事務局は日本側研究機関との協力体制を長期的に継続していくことを期待する。

（4）下痢症研究の実用化

プロジェクト関係者は iDEWS 事務局と協力し、気候予測に基づく下痢症の有病率及び発生件数の変動モデルを開発するために、更に研究を継続する必要がある。なお、下痢症の予測モデルを構築する際、将来利用可能となれば、実験室サーベイランスシステムからの病原体データの活用も検討すべきである。

５－２　教訓

<u>SATREPS プロジェクトにおける研究成果の想定されるユーザー機関（国レベル、地方レベル）の戦略的巻き込み</u>

本プロジェクトは SATRAES の下、技術協力プロジェクトの枠組みで実施される国際共同研究であり、その結果として、南アフリカと日本の研究機関が分野横断的協同研究により気候予測に基づく感染症予測モデルを開発した。また、プロジェクトは予測情報に基づく感染症予防対策にかかわるエビデンスの構築や実現可能性の高い運用指針の策定を行い、将来的には設立予定の iDEWS 事務局の下で公的サービスとして国内外の浸淫地域へ適用することをめざしている。その実現のためには、予測情報の実際のユーザー機関である州レベル行政機関（LDOH）だけではなく、国レベルの感染症分野の政策・戦略策定を担う NICD、気象・気候にかかわるサービスや研究開発を担う国家機関である SAWS の協力が必要である。プロジェクトは NICD 及び SAWS をプロジェクトの前半でメンバーに迎え入れ、SATREPS の事業目的である「研究成果の社会実装」を念頭にこれらの政策・戦略策定機関、研究成果のユーザー機関と協力の下でプロジェクトを進めてきた。これにより、終了時評価時点で南アフリカ側実施機関が中心となって iDEWS 事務局の

設立が計画され、予測情報に基づく感染症予防対策の実現に向けた他分野連携アプローチが継続する見込みである。このことはプロジェクトの「持続性」や「インパクト」を大きく高めたと認められた。

このように、プロジェクトは「研究成果の社会実装」に向けた実施体制の構築に早い段階から取り組み、研究機関間の分野横断的アプローチだけではなく、実際のユーザー機関、政策・戦略策定機関となるさまざまなレベルの行政機関も実施体制に組み入れることで、持続性やインパクトを大いに高めた。したがって、他の SATREPS の下で実施される技術協力プロジェクトにおいても、実施体制の構築には単に研究機関や監督省庁だけではなく、実際のユーザー機関や政策・戦略策定機関を含めることが効果的である。ただし、このような他分野連携の下で実施体制を構築した場合、国際連携に加えて先方機関の連携調整が困難となる可能性があることから、国内・国際的な連絡調整方法などを含むプロジェクト運営管理を適切に実施するための準備・取り組みが必要である。

付　属　資　料

1．協議議事録（MM）及び終了時評価報告書
　別添 1．PDM version 2（2016 年 10 月 4 日）
　別添 2．終了時評価調査の日程
　別添 3．評価グリッド
　　3-1　実施プロセスの検証
　　3-2　評価 5 項目
　別添 4．主要面談者リスト
　別添 5．投入実績表
　　5-1　プロジェクトメンバー表
　　5-2　JICA 専門家派遣
　　5-3　南アフリカ人研究者来日
　　5-4　本邦研修
　　5-5　現地研修
　　5-6　供与機材リスト
　別添 6．iDEWS 事務局設立意向宣言書

MINUTES OF MEETING
BETWEEN
THE JAPANESE FINAL EVALUATION MISSION
AND
AUTHORITIES CONCERNED OF
THE GOVERNMENT OF THE REPUBLIC OF SOUTH AFRICA
ON
THE JAPANESE TECHNICAL COOPERATION PROJECT FOR "ESTABLISHMENT OF AN EARLY-WARNING SYSTEM FOR INFECTIOUS DISEASES IN SOUTHERN AFRICA INCORPORATING CLIMATE PREDICTIONS"

The Final Evaluation Mission (hereinafter referred to as "*the Mission*"), organised by the Japan International Cooperation Agency (hereinafter referred to as "*JICA*"), headed by Dr. Kaname KANAI, visited the Republic of South Africa (hereinafter referred to as "*South Africa*") from 8 to 21 January 2019 for the purpose of the Final Evaluation of JICA's Technical Cooperation Project titled "*The Project for Establishment of an Early-Warning System for Infectious Diseases in Southern Africa incorporating Climate Predictions" in the Republic of South Africa* (hereinafter referred to as "*the Project*").

During their stay in South Africa, the Mission had a series of discussions with South African authorities, and both sides agreed on the matters referred to in the Attached Document of this Minutes of Meeting, which summarizes the results of the Final Evaluation Report attached hereto.

Pretoria, 21 January 2019

Dr. Kaname KANAI	Mr. Ben DURHAM
Leader	Chief Director
Final Evaluation Mission	Bio-Innovation, Department of
Japan International Cooperation Agency	Science and Technology
Japan	Republic of South Africa

Witnessed by:

Prof. Noboru MINAKAWA
Professor
Nagasaki University
Japan

Dr. Neville SWEIJD
Director
Alliance for Collaboration on Climate and Earth Systems Science
Republic of South Africa

ATTACHMENT TO THE MINUTES

The Joint Coordinating Committee (JCC) of the Project reviewed the Final Evaluation Report compiled by the Mission and agreed to its contents. The Report's conclusions and recommendations are as follows.

1. Conclusions

The Project has achieved the improvement of the climate prediction skill on the JAMSTEC SINTEX-F2 and the CSIR Variable Resolution Earth Systems Model (VrESM) and the development of downscaling techniques, especially in the Southern African Region. By utilising the improved climate prediction products, the Project also successfully developed three (3) climate-based epidemic prediction models for malaria. These three (3) models, which have different characteristics, can predict the likelihood of epidemic per season, at different, interoperable, time scales, within target range of accuracy, and the potential extent of said epidemic in once instance.

The Project provided a prediction of malaria outbreak in the 2017/2018 season, which led to timeous intervention for malaria control. However, it is necessary to make further scientific evidence to clarify the effectiveness of the intervention. On the initiative of South Africa, the iDEWS Bureau is expected to produce evidence for the optimization of operational guidelines (including countermeasures required based on predictions of outbreaks) after the Project's completion. The iDEWS Bureau is expected to disseminate the prediction results, affected areas in South Africa and even in neighbouring countries. In addition, the iDEWS Bureau is expected to further develop the prediction models, and to explore expanding the application to other regions and other fields such as agriculture, disaster preparedness, etc. in future. The Project's outcome has the potential to make a significant impact if climate forecasting information can be applied to other sectors.

Many academic papers have been published in international journals through collaborative research work under the auspices of the Project with mutual capacity development. Even after the Project's completion, it is expected that research outcomes will continue to be created as a result of the update of the malaria epidemic prediction model based on the climate forecast and the effect of measures based on the forecast information, with a number of research papers expected to be published.

In terms of the evaluation results of the Project, the "*Relevance*", the "*Effectiveness*", and the "*Sustainability*" of the Project are all high, although "*Efficiency*" is moderate due to the delay of the data collection activity and the dispatch of an expert. On the other hand, there are positive "*Impacts*" which will be expected in future practical application of the research findings and outcomes to society, at the time of the Final Evaluation. Therefore, it is considered that the Project's achievement is very high, both academically and as technical cooperation.

2. Recommendations

The Final Evaluation Team make the following recommendations in order for the Project to attain more positive impacts as well as to consolidate the sustainability.

(1) Establishment and Development of the iDEWS Bureau

The proposed iDEWS Bureau should clarify its roles and functions and commence the actual operations by May 2019 when the Project officially ends.

(2) Verification of the effectiveness of the prediction information-based interventions for the prevention and control of malaria epidemics

The iDEWS Bureau is required to verify the effectiveness of the intervention from the aspects of prevention, diagnosis and treatment of malaria, which had been taken based on the malaria outbreak prediction information, beyond the Project's completion. The iDEWS Bureau is also expected to optimize the operational guidelines for measures against malaria epidemics based on evidence and to provide information to WHO etc. to demonstrate the evidence and experiences to global activities.

(3) Dissemination of the experience to neighbouring countries

The iDEWS Bureau should take initiative for the dissemination of the Project's experience and outcomes not only to Mozambique, which shares the border with the Limpopo province, but also the member countries of the Elimination 8. The iDEWS Bureau and Japanese research institutes are expected to maintain their continuous cooperation and joint research on a long-term basis.

(4) Operationalisation of diarrhoeal disease research

The project partners, in collaboration with the iDEWS Bureau, should pursue research on the diarrhoea disease toward further development of climate-based models for the prediction of diarrhoea disease prevalence and incidence variability. The work should consider the utilisation of pathogen data from the laboratory-based surveillance system when available in future.

Attachment: Final Evaluation Report

ATTACHMENT

FINAL EVALUATION REPORT

ON

THE JAPANESE TECHNICAL COOPERATION PROJECT

FOR

ESTABLISHMENT OF AN EARLY-WARNING SYSTEM FOR INFECTIOUS DISEASES IN SOUTHERN AFRICA INCORPORATING CLIMATE PREDICTIONS

UNDER THE SCHEME OF

THE SCIENCE AND TECHNOLOGY RESEARCH PARTNERSHIP FOR SUSTAINABLE DEVELOPMENT (SATREPS)

Japan International Cooperation Agency (JICA)

and

Authorities concerned in the Republic of South Africa

21 January 2019

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ABBREVIATIONS

ACCESS	Alliance for Collaboration on Climate and Earth Systems Science
AMED	Japan Agency for Medical Research and Development
ARC	Agricultural Research Council
CSIR	Council for Scientific and Industrial Research
DST	Department of Science and Technology
DOH	Department of Health
GIS	Geographical Information System
GPS	Global Positioning System
iDEWS	(Climate Prediction-based) infectious Diseases Early Warning System
IHR	International Health Regulation
IRS	Indoor Residual Spraying
JAMSTEC	Japan Agency for Marine-Earth Science and Technology
JCC	Joint Coordinating Committee
JICA	Japan International Cooperation Agency
JST	Japan Science and Technology Agency
LAMP	Loop-mediated Isothermal Amplification
LDOH	Department of Health-Limpopo
LDOH-Malaria	Department of Health-Limpopo, Malaria Control
M/M	Minutes of Meetings
MOU	Memorandum of Understanding
NDMC	National Disaster Management Centre
NEKKEN	Nagasaki University Institute of Tropical Medicine
NDOH	National Department of Health
NGO	Non-Governmental Organizations
NICD	National Institute for Communicable Diseases
ODA	Official Development Assistance
OVIs	Objectively Verifiable Indicator(s)
PCM	Project Cycle Management
PDM	Project Design Matrix
SADC	Southern African Development Community
SAMRC	South African Medical Research Council
SATREPS	Science and Technology Research Partnership for Sustainable Development
SAWS	South African Weather Service
SOP	Standard Operating Procedure
TICAD	Tokyo International Conference on African Development
TMI	Tzaneen Malaria Institute
UCT	University of Cape Town
UL	University of Limpopo
UP	University of Pretoria
UV	University of Venda
UWC	University of the Western Cape
WHO	World Health Organization
WRF	Weather Research and Forecasting
ZAR	Zuid-Afrikaans Rand

CHAPTER 1 SCOPE OF FINAL EVALUATION

1.1 Background of the Final Evaluation

It is suggested that the epidemic[1] of certain infectious diseases such as malaria, diarrhoea and pneumonia can be affected by climate variability, in particular, air-sea interactions such as La Niña effect, seasonal variability of ambient temperature and precipitation. Southern African countries including the Republic of South Africa (hereinafter referred to as "*South Africa*") are being subject to danger of the said infectious diseases. As was just described, the relationship between climate variability and the incidence of infectious diseases is strongly suggested; nevertheless, its concrete correlative relationship has not been scientifically proven. For this reason, climate-based infectious disease epidemic prediction has not been used for practical measures for infectious diseases control to this date.

On the other hand, a climate variability prediction system with high prediction accuracy (SINTEX-F) was developed through the collaborative research of the South African and Japanese research institutes with the support of a former JICA's technical cooperation entitled "*the Project for Prediction of Climate Variations and its Application in the Southern African Region*" (2010 – 2013), which was implemented under the scheme of the Science and Technology Research Partnership for Sustainable Development (hereinafter referred to as "*SATREPS*"). On the basis of the said project, "*the Project for Establishment of an Early-Warning System for Infectious Diseases in Southern Africa incorporating Climate Predictions*" (hereinafter referred to as "*the Project*") is launched in May 2014 under the scheme of SATREPS, aiming to further improve the prediction skill of the SINTEX-F, followed by the establishment and subsequent operability verification of climate prediction-based infectious disease early-warning systems (hereinafter referred to as "*iDEWS*"), especially for malaria, diarrhoeal diseases and pneumonia.

The Final Evaluation was carried out with the objectives for grasping the whole progress of the international collaborative research as well as the generation of research findings and outcomes and for evaluating the performance of the Project, as an Official Development Assistance (ODA), from the viewpoint of human resource development, institutional functional enhancement and contribution to development subjects; further, on the basis of the evaluation results, recommendations were provided to ensure the achievement of the Project Purpose by the end of the project period as well as to consolidate the sustainability of Project's achievements.

1.2 Objectives of the Final Evaluation

The objectives of the Final Evaluation are as follows:

1) To review the overall progress of the Project and evaluate its achievements as of the time of the Final Evaluation in accordance with the five evaluation criteria ('*Relevance*', '*Effectiveness*', '*Efficiency*', '*Impact*' and '*Sustainability*') on the basis of latest version of Project Design Matrix (PDM) version 2 (Annex 1);
2) To discuss the contributing and hindering factors for the achievements of the Outputs and the Project Purpose;
3) To discuss the plan for the Project for the rest of the project period together with the South African side based on reviews and analysis of the project performances;
4) To make recommendations in order to achieve the Project Purpose as well as future practical

[1] An "*epidemic*" is defined as the rapid spread of infectious disease to a large number of people in a given population, whereas an "*outbreak*" is defined as a sudden increase in occurrences of a disease in a particular time and place and it may affect a small and localized group or impact upon thousands of people across an entire continent.

application of research findings and outcomes to the society, and to revise the PDM as necessary basis; and

5) To summarize the results of the study in a Final Evaluation Report.

1.3 Final Evaluation Team

The evaluation work of the Project was performed by three (3) JICA members in consultation with authorities concerned in South Africa. The members of the Terminal Evaluation Team (hereinafter referred to as "*the Team*") were indicated below.

Simultaneously with the JICA's review work, the Japan Agency for Medical Research and Development (hereinafter referred to as "*AMED*")[2], supporting research activities conducted in Japan under the framework of SATREPS, dispatched two (2) members and participated in the field survey in South Africa to conduct their final evaluation and to offer technical advices on the research activities from technical standpoint.

< JICA Final Evaluation Mission >

Name	Designation	Title and Affiliation	Duration of Survey
Dr. KANAI Kaname	Leader	Executive Technical Advisor to the Director General, Human Development Department, JICA	12/Jan/2019 – 23/Jan/2019
Ms. KAWAGUCHI Misaki	Cooperation Planning	Assistant Director, Health Team 2, Health Group 1, Human Development Department, JICA	12/Jan/2019 – 23/Jan/2019
Dr. INOUE Yoichi	Evaluation Analysis	Senior Consultant, Consulting Division, Japan Development Service Co., Ltd.	7/Jan/2019 – 23/Jan/2019

<AMED Mission Members >

Name	Designation	Title and Affiliation	Duration of Survey
Prof. Dr. WATANABE Haruo	Infectious Diseases Control Research	Program Supervisor, International Collaborative Research Program, Department of International Affairs, AMED Professor, the Graduate School of the International University of Health and Welfare	12/Jan/2019 – 21/Jan/2019
Mr. ISHII Katsumi	Planning and Evaluation	Deputy Manager, Division of International Collaboration, Department of International Affairs, AMED	12/Jan/2019 – 21/Jan/2019

The on-site evaluation work was conducted from the 8th of January to the 22nd of January 2019. This evaluation included site visits, interviews and scrutinizing various documents and data related to planning, implementation and monitoring processes of the Project (Annex 2).

1.4 Framework of the Project

The framework of the Project is described below.

1) Project Period: Five (5) years from the 12th of May 2014 to the 11th of May 2019.
2) Project Management: The administration system of the Project is as follows:
   - The Chief Director of the Biotechnology, the Department of Science and Technology

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[2] Affairs under the jurisdiction and authorities of the projects in the field of infectious disease control was transferred to AMED. The transfer took place on the 1st of April 2015.

(hereinafter referred to as "*DST*") is assigned as the Project Director;

- The Chief Director of the Communicable Diseases, the Department of Health (hereinafter referred to as "*DOH*") is assigned as the Project Co-Director[3];
- The Director of the Alliance for Collaboration on Climate and Earth Systems Science (hereinafter referred to as "*ACCESS*") is assigned as the Project Manager; and
- The Professor of the Department of Vector Ecology and Environment of the Nagasaki University Institute of Tropical Medicine (hereinafter referred to as "*NEKKEN*") is assigned as the Chief Advisor.

3) Implementing Agency: Project Implementers (research institutes) of the Project are indicated as follows:

The South African Side: ACCESS; the South African Medical Research Council (SAMRC); the Council for Scientific and Industrial Research (CSIR); the National Institute for Communicable Diseases (NICD)[4]; the South African Weather Service (SAWS)[5]; the Limpopo Department of Health (LDOH); the Department of Health-Limpopo, Malaria Control (LDOH-Malaria); the University of Cape Town (UCT); the University of Limpopo (UL); the University of Pretoria (UP)[6], the University of Venda (UV)[7]; and the University of the Western Cape (UWC)

The Japanese Side: NEKKEN and the Japan Agency for Marine-Earth Science and Technology (hereinafter referred to as "*JAMSTEC*")

4) Beneficiaries: The direct and indirect beneficiaries of the Project are 46 researchers of the South African project implementers and approximately 5.4 million peoples living in the Limpopo province, respectively.

5) The Narrative Summary of the Project:

The Narrative Summary of the Project (Project Purpose, Outputs and Activities) set in the latest PDM (version 2), authorized for revision from version 1 at the 3rd Joint Coordinating Committee (hereinafter referred to as "*JCC*") held on the 4th of October 2016, is described below.

Please refer to the Annex 1 (PDM version 1) for other elements of PDM such as the Objectively Verifiable Indicators (OVIs), means of verification, the Inputs from both sides to the Project, the Preconditions and the Important Assumptions.

Narrative Summary of PDM version 2

Project Purpose	A climate-based early-warning system model for infectious diseases control is established as a precursor for further application across southern Africa.
Outputs	Output 1 Climate-based infectious disease epidemic prediction models are developed especially for malaria, pneumonia and diarrhoea.

[3] Replaced from the Chief Director of the District Health Services, the NDOH. Accordingly, the Memorandum of Understanding (hereinafter referred to as "*MOU*") dated on the 12th of May 2014 was amended by exchanging the Minutes of Meetings (hereinafter referred to as "*M/M*") between the DST and JICA on the 10th of November 2015.

[4] The NICD was authorized as a South African member of the Project at the time of the 2nd JCC held in October 2015.

[5] The SAWS was authorized as a South African member of the Project from an external supporting organization at the time of the 2nd JCC held in October 2015.

[6] The UP was authorized as a South African member of the Project at the time of the 1st JCC held in August 2014.

[7] The UV was authorized as a South African member of the Project at the time of the 1st JCC held in August 2014.

	Output 2 Operational guidelines of iDEWS are developed in the Limpopo Province. Output 3 Prediction performance and operability of the iDEWS are verified.
Activities	Activities under Output 1 1-1. Prospective and retrospective data/information acquisition systems are developed in the areas of infectious diseases and climate variability 1-1-1. To develop databases of data/information of malaria, pneumonia and diarrhoea respectively from local health information system, archival records of health facilities and so on. 1-1-2. To determine investigation target sites on the basis of a risk map for respective diseases, which is developed using retrospective data from the database. 1-1-3. To conduct fact-finding surveys at communities in the targeted sites with regard to incidence and prevalence of respective diseases (including undiagnosed diseases), residents' behaviour that impacts on the prevalence (health seeking behaviour, etc.) and hygienic environment (water quality, air pollution, malaria mosquito insecticide resistance etc.), followed by populating the data into the database. 1-1-4. To source climatic and non-climatic ancillary environmental data (geographic data, etc.) from ACCESS partner organizations such as SAWS and ARC. 1-1-5. To observe local-scale meteorological data in the target sites by placing basic observation stations at public buildings. 1-2. Elucidation of relationships among incidence/prevalence of the target diseases and climate variability (ambient temperature, humidity, precipitation, etc.). 1-2-1. To investigate the relationship between incidence/prevalence of the target diseases and climate variability using time-series analysis. 1-2-2. To investigate the relationships of proliferation of malaria vectors with climate variability and malaria incidence/prevalence. 1-2-3. To investigate the relationship between regional-scale climate variations in the Limpopo Province and their links with the global climate phenomena such as the El Nino Southern Oscillation (ENSO), the Indian Ocean Dipole Mode (IODM) and the Sub-tropical Dipole Mode (SDM). 1-3. Development of infectious disease mathematical and/or statistical models for malaria, and statistical models for pneumonia and diarrhoea of which local epidemic situation is reflected 1-3-1. To review existing infectious disease models (related to climate in particular) for malaria, cholera, and pneumonia. 1-3-2. To develop basic mathematical and/or statistical models for malaria, and statistical models for pneumonia and diarrhoea by modifying existing model(s) or newly developing. 1-3-3. To calibrate the models by verifying their prediction performance using retrospective and prospective data/information of infectious diseases obtained from the database. 1-4. Improvement of a seasonal prediction system based on an ocean-atmosphere coupled general circulation model (CGCM) called SINTEX-F; improving its skill, downscaling, extending its lead-time 1-4-1. To improve the prediction accuracy of SINTEX-F for the short-term seasonal climate variability by enhancing model resolution, implementing better physics and data assimilation in next versions of SINTEX-F on the Earth Simulator. 1-4-2. To reduce model biases by model validations and intercomparisons among SINTEX-F1, new SINTEX-F2 and other climate models developed in South Africa. 1-4-3. To improve resolution and lead time for climate prediction of the SINTEX-F for better local-scale prediction performance by using a dynamical downscaling model such as Weather Research and Forecasting model (WRF) and statistical downscaling techniques. 1-4-4. Interactively with the Activity 1-4-3, to fine-tune WRF downscaling model using local data available from the weather and climate observations at the target areas (Activity 1-1). 1-5. Development of the climate-based infectious disease prediction models for malaria, pneumonia and diarrhoea

1-5-1. To develop a climate-based infectious disease epidemic prediction models for malaria, pneumonia and diarrhoea by coupling the infectious disease mathematical and statistical models and the adopted climate prediction model, in light of the relationships among incidence/prevalence of the target diseases, climate variability and proliferation of vectors (Activity 1-2).

1-5-2. To calibrate the models by verifying their prediction performance using existing data/information of infectious diseases epidemics and outbreaks obtained from the database.

Activities under Output 2

2-1. To launch a preparatory committee for introducing the iDEWS at the Limpopo Province consisting of organizations responsible for epidemic prediction, issuing epidemic/alerting information and implementing countermeasures based on such information.

2-2. To set criteria for outbreak alerting.

2-3. To set communication flow of infectious diseases epidemic/outbreak information in the Limpopo Province.

2-4. To develop an iDEWS operational Guidelines comprising regular reporting of epidemics, issuing outbreak alerting and consequent countermeasures, organogram of iDEWS operation, formats of regular reporting and alerting, etc.

Activities under Output 3

3-1. To evaluate the prediction performance and operability of the iDEWS through a pilot application at the Limpopo Province.

3-2. To conduct table-top exercises regarding issuing outbreak alerting and consequent countermeasures at the Limpopo Province.

3-3. To develop a sustainable monitoring and evaluation system for assessing impacts of the iDEWS on infection control at the Limpopo Province.

3-4. To verify the applicability of other areas using available data of epidemics, climate and non-climate environment at other provinces of the South Africa and neighbouring countries.

3-5. To hold workshop(s) geared to administrative officers, researchers, etc. in the areas of climate variability and infection control from the government of the South Africa and neighbouring countries for the deployment of iDEWS.

3-6. To start discussions with administrative officers, researchers, etc. in the areas of climate variability and infection control of the government of the South Africa for the dissemination of iDEWS.

CHAPTER 2 METHOD OF THE FINAL EVALUATION

2.1 Framework of Project Evaluation under the Scheme of SATREPS

Since SATREPS provides assistances to the counterpart countries through the implementation of technical cooperation project on site by JICA and the technical and financial support for research works in Japan by AMED in a collaborative manner, it is natural that review and evaluation works on site are conducted in tandem in consideration of its efficiency.

JICA, in consultation with governmental organizations and/or research institutes including researchers, will review and evaluate the performance and achievement of the technical cooperation project implemented under the framework of the Japan's ODA from the viewpoint of human resource development, capacity development, and contribution to development agenda at partner countries. AMED will evaluate the whole of international joint research works from the viewpoint of research outcomes that contribute to resolve the global issues.

2.2 Methodology of Evaluation

The Final Evaluation was performed in accordance with the latest "*JICA Guidelines for Project Evaluation Second Edition*" and "*JICA Handbook for Project Evaluation (Ver. 1)*" issued in May 2014 and August 2015, respectively. Achievements and implementation process were assessed based on the investigation results, which are consolidated in the evaluation grid (Annex 3), from the aspects of the five evaluation criteria of relevance, effectiveness, efficiency, impact, and sustainability, as well as the verification of implementation process.

The Team conducted evaluation surveys at the project sites through questionnaires and interviews to counterpart researchers, other related organizations, and the JICA experts involved in the Project to review the Project on the basis of the evaluation grid. See Annex 4 "*List of Interviewees*" for more information.

Project performances including achievement of the Objectively Verifiable Indicators (OVIs) were reviewed and analysed in accordance with the Project Cycle Management (PCM) concept. The review work was performed by the Japanese members in consultation with the authorities concerned in the South African side on the basis of PDM version 2 (See Annex 1 for more information). Finally, the Team compiled this Final Evaluation Report.

2.3 Five Evaluation Criteria

Description of the five evaluation criteria that were applied in the analysis for the Final Evaluation is given below.

Five Criteria	Description
Relevance	Relevance of the Project is reviewed by the validity of the Project Purpose and Overall Goal in connection with the government development policy and the needs in the South Africa. Relevance of the Project is verified on the basis of facts and achievements at the time of the Final Evaluation.
Effectiveness	Effectiveness is assessed to what extent the Project has achieved its Project Purpose, clarifying the relationship between the Project Purpose and Outputs. Effectiveness of the Project is verified on the basis of facts and achievements at the time of the Final Evaluation.
Efficiency	Efficiency of the project implementation is analysed with emphasis on the relationship between Outputs and Inputs in terms of timing, quality and quantity. Efficiency of the Project is verified on the basis of facts and achievements at the time of the Final Evaluation.
Impact	Impact of the Project is assessed in terms of positive/negative, and intended/unintended influence caused by the Project. Impact of the Project is verified on the basis of extrapolation and expectation at the time of the Final Evaluation.
Sustainability	Sustainability of the Project is assessed in terms of political, financial and technical aspects by examining the extent to which the achievements of the Project will be sustained after the Project is completed. Sustainability of the Project is verified on the basis of extrapolation and expectation at the time of the Final Evaluation.

CHAPTER 3 PROJECT PERFORMANCE AND ACHIEVEMENTS

3.1 Inputs

1) Input from the Japanese Side

The following are inputs from the Japanese side to the Project as of January 2019. See Annex 5 for more information.

Components	Inputs
Dispatch of Japanese Experts	Long-term Experts: a total of 3 Experts (Epidemiology/medical entomology research and Project Coordinator), 101 M/M (Man/Month) Short-term Experts: a total of 16 Experts, 71.7 M/M (1148 days in total)
Provision of Equipment	Major Items: Automatic Weather Observation System, research / laboratory instrument and related equipment such as microscopies, artificial environment test system, personal computers for data processing and analyses, software for data analyses, etc. (JPY 33,825,724 (≒ approx. ZAR 4,084,245 ≒ USD 298,359) [8]
Invitation of Researchers from Abroad	Total number: 23 persons Content: Discussion of the research direction and methods regarding the prediction of climate variability in Southern Africa and the participation and presentation at the project open symposium (35 persons, a total of 347 days)
Training in Japan	Total number: 7 persons Content: – Theory and practice of statistical methods for the development of the Geographical Information System (GIS)-based infectious diseases risk mapping (2 persons at NEKKEN for 22 days) – Theory and practice of statistical methods for correlation analyses between the incidence of infectious diseases and meteorological data (1 person at JAMSTEC for 21 days) – Theory and application of local climatology information and physical mechanisms of climate variability (3 persons at JAMSTEC for 30 days) – Data quality control & cleaning and descriptive sample analysis (1 person at JAMSTEC for 14 days)
Overseas Activities Costs	Total Costs: ZAR 3,160,529 (≒ USD 230,880) [9] – JFY2014: ZAR 488,990 – JFY2015: ZAR 676,288 – JFY2016: ZAR 673,410 – JFY2017: ZAR 715,270 – JFY2018: ZAR 606,571 Expenditure: Travel cost, Consumables for research activities, Communication cost.

2) Input from the South African Side

The followings are inputs from the South African side to the Project as of January 2019. See details on the Annex 5.

Components	Inputs
Allocation of Counterpart Researchers	A total of 57 researchers as well as administrative and technical officers 1. one (1) from ACCESS; 2. Fourteen (14) from SAMRC; 3. Eight (8)[10] from CSIR; 4. One (1) from NICD; 5. Six (6) from SAWS 6. Two (2) from LDOH 7. Four (4) from LDOH-Malaria;

[8] JICA Conversion rates at each fiscal year's last month was used for currency conversion.
[9] JICA Conversion rates at each year was used for currency conversion.
[10] One out of 8 researchers was transferred to the University of the Witwatersrand, Johannesburg in January 2019.

	8. Three (3) from UCT; 9. Eight (8) from UL; 10. Four (4) from UP; 11. Four (4) from UV; and 12. Two (2) from UWC
Facilities, Equipment and Materials	1. Project office spaces in CSIR and LDOH-Malaria; 2. Laboratory and office space un LDOH-Malaria; 3. Existing research instruments, equipment and/or devices in the South African counterpart organizations; 4. Available data, information and/or specimens related to the Project; and 5. Availability of teleconference system in CSIR
Local costs	● South African DST has allocated a total of ZAR 5,700,000 in cash to the Project for local travel costs, field work and equipment purchases, as well as to be used to initiate the iDEWS Bureau. ● ACCESS provided bursaries to one Ph.D. and two M.Sc. students (local) for work on the Project. ● Costs for field survey in the Limpopo province, the development of database for hospital inpatients information, domestic transportation of the South African counterpart personnel, utilities for the project office, consumables used for the project activities, custom clearance of the materials procured in Japan such as research instruments and reagents, etc.

3.2 Achievements of the Project

1) Achievements of the Project Activities

Achievements of the Project Activities under Outputs are as indicated below.

Output 1 Climate-based infectious disease epidemic prediction models are developed especially for malaria, pneumonia and diarrhoea.	
Activities	Performances
1-1. Prospective and retrospective data/information acquisition systems are developed in the areas of infectious diseases and climate variability	
1-1-1. To develop databases of data/information of malaria, pneumonia and diarrhoea respectively from local health information system, archival records of health facilities and so on.	● The Project, at the initiative of the LDOH-Malaria and NEKKEN, has been gathering malaria incidence data in the Limpopo province from the year of 1998 when rapid diagnosis test kits were introduced for the diagnosis of Malaria into a database. Following the Midterm Review, the Project has developed a system of automatic data forwarding to the database daily, of which variables are used by the climate-based malaria prediction model. In addition, the Project has also developed a system of data transferring of the data from a malaria reporting system using cell phone on a quasi-real-time basis. By constructing such an automatic data transfer system, labour saving of data input and prevention of input error are improved. In addition, since the data used in the prediction model is always the latest, it is considered that the construction of the automatic data transfer system greatly contributes to the maintenance and improvement of the prediction accuracy and the quality assurance of the model. Data of new malaria cases are being added and the number of registrations in the database was approx. 120 thousand as of December 2018. ● The Project, at the initiative of the SAMRC and the ACCESS, had been working on the registration of all inpatients' information of the *Nkhensani* Hospital in the Greater Giyani and the *Maphutha L. Malatji* Hospital in the Phalaborwa District Municipality (a total of 44,159 registrations, from 2002 to 2016). The collected data was subjected to data cleaning for secure its quality. ● The ACCESS obtained information of insurance claims with the diagnosis of pneumonia as well as diarrhoea from the insurance company by their own efforts (approx. 60,000 – 80,000 cases). The ACCESS also gained the sales amount data of non-prescription anti-diarrhoeal drug (*Loperamide*), which can reflect the incidence of mild diarrhoeal cases that are not required to see a doctor. ● Construction work for the database of malaria incidence had been progressing smoothly; whereas that of pneumonia and diarrhoea were 6 –

	12 months behind the schedule as of the time of the Mid-term Review since it took longer-than-expected time for the South African side to allocate budget for the construction of the database, and to computerize a huge amount of paper-based information. Having said that, the construction work of database of diarrhoea as well as pneumonia for analyses was completed by April 2017.
1-1-2. To determine investigation target sites on the basis of a risk map for respective diseases, which is developed using retrospective data from the database.	● The LDOH-Malaria, jointly with NEKKEN, develop a malaria risk map using extracted data from the database. The Project chose the Greater Giyani Municipality and the Vhembe District Municipality as the target area for investigation on the basis of the risk map. ● The Project, as a result of the discussions amongst member organizations, chose the Greater Giyani as the target area for pneumonia and diarrhoea research, the same area with that for malaria, in consideration of the efficient implementation of field activities when needed, since the distribution of the incidences of pneumonia and diarrhoea were equable in the whole area of the Limpopo province, whereas several hot spots are observed in malaria incidences.
1-1-3. To conduct fact-finding surveys at communities in the targeted sites with regard to incidence and prevalence of respective diseases (including undiagnosed diseases), residents' behaviour that impacts on the prevalence (health seeking behaviour, etc.) and hygienic environment (water quality, air pollution, malaria mosquito insecticide resistance etc.), followed by populating the data into the database.	● The Project, at the initiative of the LDOH-Malaria, the SAMRC and NEKKEN, conducted investigation of the prevalence of asymptomatic malaria infection by testing community residents (approx. 500 households in the Greater Giyani) with a LAMP-based diagnostic test from the epidemic season of 2015/2016. The prevalence information of asymptomatic malaria carriers is necessary to assess whether the risk of outbreaks has truly been eliminated even if the reporting of infected persons has decreased significantly, particularly when the number of patients reporting malaria has decreased at a level close to exclusion, such as South Africa. Besides, the prevalence of asymptomatic malaria carriers is necessary information to maintain the predictive accuracy of its prediction model when the number of reported cases decreases, because the predictive accuracy of the model decreases when the number of reported patients decreases. ● The Project investigated the implementation record of the Indoor Residual Spraying (IRS) in the same area and added those data into the database. ● The Project placed light trap for malaria vector mosquito of anopheles in the 2015/2016 epidemic season; however, enough amount of imaginal anopheles could not be captured to implement the experiments (e.g. insecticide resistance) due to the low mosquito density. For this reason, the Project used existing data of imaginal anopheles in the LDOH-Malaria as well as reports of other research groups for the development of the prediction models as references. Information on the insecticide resistance is not expected to be used to develop predictive models for malaria epidemics, but rather is expected to be used as information for preventive measures under iDEWS. ● The Project, at the initiative of the SAMRC, also conducted investigation for three times from 2015/2016 season with regard to residents' health seeking behaviour that impacts on the epidemic of communicable diseases as well as hygienic environment and air pollution in the communities that can influence the incidences of diarrhoea and pneumonia. The results of these analyses are not considered as variables for the development of predictive models, but are supposed to be used as a basis for interpreting or explaining the causal relationship between climatic variables and infectious disease epidemics and for taking measures in case that an increase in the number of patients is predicted.
1-1-4. To source climatic and non-climatic ancillary environmental data (geographic data, etc.) from ACCESS partner organizations such as the South African Weather Service (SAWS) and the Agricultural Research Council (ARC).	● JAMSTEC, with the support of NEKKEN and the UL, gained satellite observation-based climatic data as well as non-climatic ancillary environmental data (e.g. geographic data) from the ACCESS partner organizations, and used them for improving the existing seasonal prediction system based on an ocean-atmosphere coupled general circulation model (SINTEX-F) (for the development of SINTEX-F2) and for the development of communicable diseases risk maps. ● Meanwhile, it was supposed that the terrestrial climate data will be provided by the ARC and the SAWS to the Project; nevertheless, the said data was not provided by the ARC. However, though it took longer-than-expected time, a contract for the provision of the terrestrial data from the SAWS was eventually concluded in August 2016; the said data has just become available for the Project. However, the terrestrial climate data were supposed to be used for the verification of the skill of the downscaled climate prediction; thus, this delay in the signing of the contract has less

	influence on the development of SINTEX-F2. ● The SAWS was regarded as an external supporting agency at the beginning of the Project, but was authorized as an official member of the Project at the time of the 2nd JCC held in October 2015.
1-1-5. To observe local-scale meteorological data in the target sites by placing basic observation stations at public buildings.	● The Project, at the initiative of the ACCESS the LDOH-Malaria and the NEEKEN, installed a total of 7 Automatic Weather Observation Systems at the cooperative health facilities in the Greater Giyani by the year of 2015, and the collection of terrestrial climate data is being done. ● The SAWS is covering whole land of the South Africa for the collection of terrestrial climate data, whereas the Project can obtain the said data in detail and immediately in the target areas. ● Following the cooperation period of the Project, it is anticipated that those data collection as well as the maintenance of the said System are continued by the South African side under the iDEWS Bureau (the details of the Bureau will be described later).
1-2. Elucidation of relationships among incidence/prevalence of the target diseases and climate variability (ambient temperature, humidity, precipitation, etc.).	
1-2-1. To investigate the relationship between incidence/prevalence of the target diseases and climate variability using time-series analysis.	● The Project, at the initiative of NEKKEN and JAMSTEC, revealed the significant correlation between the number of malaria patients and climate variation (temperature and precipitation amount) using several types of time-series as well as spatial statistical analyses on the data available since 1998. To be more precise, the analyses demonstrated the positive correlation of the number of the malaria patients with the precipitation amount in the southern part of Mozambique and Zimbabwe as well as the easterly wind, and the negative correlation with the sea surface temperature; in particular, the positive correlation with La Niña. The Project also performed the analyses on the seasonal variation in the said correlation. ● As for diarrhoea, contour analysis of data on the number of diarrhoeal patients and climatic variables from the target hospitals showed that there is a tendency for an increase in the number of children under five years of age with continuous rainfall in case of no continuous rainfall (drought) or, contrary, continuous rainfall in winter season, and those correlation increased with the inclusion of a lag of eight weeks. The Project also observed an increasing trend in the number of patients with diarrhoea in 2010-2011 and 2015, where El Niño events were occurring. In general, Southern Africa is prone to droughts when El Nino events occur. In addition, there was a similar trend in the number of insurance claims for company diarrhoea treatment to the health insurance company, and a statistically significant negative correlation was observed in sales of an anti-diarrhoeic drug (loperamide) over the past decade with El Niño events as well as SST in the Mozambique Strait. This can be explained by the tendency of decrease in southern African precipitation as SST of the Mozambique Strait decreases. Further, it was clarified that the number of insurance claims for the treatment of diarrhoea was linked with the Indian Ocean subtropical dipole mode phenomenon; particularly, the number of insurance claims for diarrhoea treatment tended to increase when the negative mode occurs (SST of the southern Africa vicinity comparatively lowers), even if the El Niño was not generated. ● Concerning pneumonia, preliminary analysis showed no significant correlation between pneumonia case anomalies and sea-surface temperature (SST) anomalies. Thereafter, the Project performed composite analyses, which showed a strong association between higher-than-normal pneumonia annual incidence and higher-than-normal diurnal temperature range, indicating that the difference between the highest temperature of the day and the lowest temperature of the night become wider, the number of pneumonia patients become greater. Having said that temperature was the only climate variable that demonstrated a correlation with the incidence of pneumonia.
1-2-2. To investigate the relationships of proliferation of malaria vectors with climate variability and malaria incidence/prevalence.	● As was shown in the Activity 1-1-3, the Project unfortunately could not obtain enough amount of wild anopheles to analyse such as the relationship between vector mosquito and climate variability or malaria prevalence. Given that the Project can capture enough anopheles in the coming epidemic season of 2016/2017, correlation analyses are supposed to be performed immediately. ● The Project was unable to establish an observation system for imaginal mosquitoes that directly affect malaria infection. However, since a total of

	29 larval sources were identified, the Project could establish an observation system for larvae. Analyses of the Project suggest that transitions in the sources of vector mosquito may correlate with climatic variables; thus, the Project is continuing activities for accumulating relevant data. Given that this correlation is proved, the prediction accuracy is expected to be further improved by utilizing the related data as the variables of the prediction model. ● The Project also confirmed that body length (length of feathers) of vector mosquitoes and number of eggs laid were strongly correlated with temperature by indoor experiments using the artificial environment test system at the Tzaneen Malaria Institute (TMI). These findings had been used to develop a mathematical model-based malaria epidemic prediction model that South Africa is leading.
1-2-3. To investigate the relationship between regional-scale climate variations in the Limpopo Province and their links with the global climate phenomena such as the El Nino Southern Oscillation (ENSO), the Indian Ocean Dipole Mode (IODM) and the Sub-tropical Dipole Mode (SDM).	● JAMSTEC, using SINTEX-F2, revealed that the climate in southern Africa including the Limpopo province is prone to be affected by ENSO as well as IOD and SDM, of which mechanisms would further be clarified. In addition, a further study suggested that the sea-ice variability in the Weddell Sea also affects subtropical high variations that generate the SDM. ● JAMSTEC also discovered the decadal change in the precipitation in southern Africa on top of inter-annual or seasonal variation from the analyses of meteorological observation data. Further, the analyses results using SINTEX-F2 demonstrated a strong correlative relationship between the said decadal change and other decadal change in sea surface temperature as well as pressure that moves eastward from southern Atlantic to southern Indian Ocean. ● In this regard, the Project points out that the possibility of positive correlation between the decadal climate change in southern Africa and the malaria incidence in the Limpopo province. A new climate mode in the southwestern Indian Ocean was discovered. This mode represented as a dipole in the SST anomalies (east and south of Madagascar), influences the rainfall and malaria incidences in Vhembe not only on interannual but also on decadal time scales.
1-3. Development of infectious disease mathematical and/or statistical models for malaria, and statistical models for pneumonia and diarrhoea of which local epidemic situation is reflected	
1-3-1. To review existing infectious disease models (related to climate in particular) for malaria, cholera, and pneumonia.	● There are several prediction models for the incidence of communicable diseases; to be more specific, statistical models that causally infer the relationship between past malaria incidence data and meteorological data, as well as mathematical model that infer the characteristics of various phenomena (malaria incidence in this case) by expressing it with mathematical formula. The Project, at the initiative of NEKKEN and JAMSTEC, reviewed existing infectious disease models for the prediction of the incidence of malaria, pneumonia and diarrhoea during the 1st half of the project period. ● The review results showed that statistical models are mainly used for the prediction of the incidence of pneumonia and diarrhoea. On the other hand, there are several mathematical models derived from the Ross–Macdonald Model for the prediction of malaria transmission. The VECTRI model is a brand-new model of the said mathematical model, which takes the ecology of vector mosquito into consideration. The Project made a contact with the developer of the VECTRI model and obtained the source code information from him.
1-3-2. To develop basic mathematical and/or statistical models for malaria, and statistical models for pneumonia and diarrhoea by modifying existing model(s) or newly developing.	● NEKKEN and JAMSTEC developed several statistical models that take the climate (precipitation and ambient temperature) into consideration on the basis of time-series and spatial analysis of malaria incidence in the Limpopo province. Additionally, JAMSTEC developed a mathematical model for malaria transmission by adding meteorological factors to the said VECTRI model. The VECTRI model was tested for the hindcast period of 1998 to 2015 and has shown ability in forecasting the number of malaria cases over the Vhembe District Municipality in February. Though this model has a possibility to provide significantly high prediction performance given that the developing work were completed, JAMSTEC understand that there is a room for further improvement as of the time of the Final Evaluation, and presented an intention to continue the developing work even following the end of the In parallel with the above-mentioned research activities in Japan, the UWC is working on the development of mathematical models for malaria incidence prediction independently and published two research article in

	international journals. The UP has developed an individualistic ensemble climate forecast-based linear statistic model for the prediction of malaria epidemic with sufficient prediction performance for practical use (correlation coefficient between predicted and actual values demonstrates around 0.8). The UP has presented an intention to commence a model development work for diarrhoea given that necessary data were provided. ● Meanwhile, as described in the Activity 1-2-1, the Project performed correlation analyses of climatic variables with the increase of patients of each disease, i.e., diarrhoea and pneumonia. As for diarrhoea, since the correlation of the number of diarrhoea cases with multiple climatic variables as well as climatic phenomena was confirmed, it became clear that the epidemic prediction model could be developed. Currently, the Project has begun a preliminary examination of the development of predictive models for diarrhoea. However, the weather variables correlated with the number of patients for pneumonia are only temperature, and it is technically difficult to predict the diurnal temperature range; therefore, it has become clear that the development of climate-based epidemic prediction models for pneumonia is difficult at present.
1-3-3. To calibrate the models by verifying their prediction performance using retrospective and prospective data/information of infectious diseases obtained from the database.	● NEKKEN, JAMSTEC and the UWC, in charge of the development of prediction models for malaria incidence, have conducted a verification and subsequent fine tuning of their own models using retrospective and prospective data and/or information at the time of the Final Evaluation. ● Prediction models for diarrhoea incidences are also supposed to be verified and fine-tuned using retrospective data once trial models are developed. The Project, nevertheless, has just commenced a preliminary examination for the development of endemic prediction models at present; thus, it is anticipated that those development works will not have completed within the project period (the 11th of March 2019 is the due date). Having said that both the South African and the Japanese member organizations have presented clear intention for the continuation of joint work under the iDEWS Bureau (the details will be described later) even following the termination of the Project.
1-4. Improvement of a seasonal prediction system based on an ocean-atmosphere coupled general circulation model (CGCM) called SINTEX-F; improving its skill, downscaling, extending its lead-time	
1-4-1. To improve the prediction accuracy of SINTEX-F for the short-term seasonal climate variability by enhancing model resolution, implementing better physics and data assimilation in next versions of SINTEX-F on the Earth Simulator.	● In 2015, JAMSTEC had succeeded in developing a novel CGCM-based seasonal prediction system on the basis of the SINTEX-F (i.e. SINTEX-F2) with further enhanced resolution and by taking the influence of Antarctic sea ice. Also, we have introduced a new ocean data assimilation method that takes three-dimensional observed ocean temperature and salinity into account. The new systems successfully improved its prediction accuracy on SDM in southern Indian Ocean, IODM as well as precipitation in southern Africa in the austral summer season. In addition, by extending the prediction lead time to one decade, we have identified that the SINTEX-F2 model has ability in predicting the observed decadal sea-surface temperature (SST) variability in the southern Indian Ocean and the South Atlantic, which greatly affects long-term variability in the southern African rainfall. The SINTEX-F2 was developed on the basis of a 108-member ensemble prediction system for the first time in the world. The large number of ensemble members help in capturing more signals and improve the probability density function of the predictions (such as extreme ENSO, IOD and other climate events). It also helps in developing better probabilistic forecasts.
1-4-2. To reduce model biases by model validations and intercomparisons among SINTEX-F1, new SINTEX-F2 and other climate models developed in South Africa.	● JAMSTEC completed the development of the SINTEX-F2; nevertheless, is supposed to continue fine tuning of it by intercomparing with other climate models for further improvement of prediction skill. ● The CSIR and the UP, in parallel with JAMSTEC, are working on the development and fine tuning of their own seasonal climate prediction models as well as continuing information and technology exchanges with JAMSTEC. ● The South Africa and Japanese sides have reached an agreement for the development of a multi-model ensemble prediction system by averaging out the models developed by both South Africa and Japanese research institutes.

1-4-3. To improve resolution and lead time for climate prediction of the SINTEX-F for better local-scale prediction performance by using a dynamical downscaling model such as Weather Research and Forecasting model (WRF) and statistical downscaling techniques.	● JAMSTEC has succeeded in downscaling of global seasonal forecasting provided from SINTEX-F2 into local-scale prediction covering as narrow as approx. 10km^2. JAMSTEC and the CSIR jointly investigated the performance of the dynamical downscaling model, and confirmed the significant improvement of prediction accuracy in ambient temperature and precipitation, which are susceptive of the complex topography in South Africa. ● Further, the terrestrial climate data of the SAWS become available by the time of the Mid-term Review, the Project is continuing research activities for further improvement of prediction skill and lead time using the terrestrial data in addition to the satellite observation-based climate data thereafter.
1-4-4. Interactively with the Activity 1-4-3, to fine-tune WRF downscaling model using local data available from the weather and climate observations at the target areas (Activity 1-1).	● Meanwhile, the UP had succeeded in developing an individualistic ensemble climate forecast model and subsequent downscaling. Each research outcome is published in international Journals as of the time of the Final Evaluation. ● The SINTEX-F2 data was downscaled over the southern Africa region using the WRF model and the biases in the WRF models were corrected using statistical techniques. The downscaled data was used to drive the VECTRI malaria model and also the statistical model at NEKKEN. The downscaled data was also used to study the onset of summer rains over South Africa which can influence the onset of malaria season over South Africa to a certain extent.
1-5. Development of the climate-based infectious disease prediction models for malaria, pneumonia and diarrhoea	
1-5-1. To develop a climate-based infectious disease epidemic prediction models for malaria, pneumonia and diarrhoea by coupling the infectious disease mathematical and statistical models and the adopted climate prediction model, in light of the relationships among incidence/prevalence of the target diseases, climate variability and proliferation of vectors (Activity 1-2).	● NEKKEN and JAMSTEC has just commenced developing a "*climate-based malaria epidemic prediction model*" by coupling dynamically-downscaled climate prediction data with malaria epidemic prediction model(s) from the year of 2016. ● NEKKEN and JAMSTEC developed two basic models with high practicality to predict malaria epidemics: the non-linear statistical model by NEKKEN and the machine-learning-based model by JAMSTEC. Although the accuracy and characteristics of each prediction model are explained later, both models have demonstrated sufficient predictive accuracy to be used for malaria epidemic control measures; therefore, it can be said that the development of malaria epidemic prediction models could be completed in the Project. ● The UP had developed an individualistic ensemble climate forecast-based malaria epidemic prediction statistical model as of the time of the Final Evaluation. This model provides a prediction of entire 3-month malaria epidemic season from January to March in November (1-month lead-time) with high accuracy, demonstrating that the correlation coefficient between the predicted and actual number of malaria cases was as high as 0.8. The UP is working on drafting an research paper concerning this research outcome in an international journal as of the time of the Final Evaluation. At the moment, JAMSTEC is still working on the development of VECTRI model-based malaria epidemic prediction models, and also, the UWC is developing mathematical models for that purpose, but they have not been reaching certain levels enough to apply for practical malaria control measures. Research for improvement is expected to continue hereafter. ● On the other hand, as mentioned above, the number of patients with diarrhoea was confirmed to be correlated with climatic variables as well as climatic events; subsequently, preliminary development work of a model for predicting epidemics based on climate predictions has just been launched, and is expected to continue by the iDEWS Bureau even following the completion of the project period. Meanwhile, it became clear that the development of pneumonia epidemic prediction model based on the climate prediction was difficult from a technical point of view at present.
1-5-2. To calibrate the models by verifying their prediction performance using existing data/information of infectious diseases epidemics and outbreaks obtained from the database.	● NEKKEN and JAMSTEC had completed the developing work of the climate-based malaria epidemic prediction models as described above by verifying and fine tuning them on the basis of previous data. ● As was described in the Activity 1-3-3, prediction models for pneumonia incidences are also supposed to be verified and fine-tuned using retrospective data once trial models are developed.

Output 2 Operational guidelines of the climate prediction-based infectious diseases early warning system (iDEWS) are developed in the Limpopo Province.	
Activities	Performances
2-1. To launch a preparatory committee for introducing the iDEWS at the Limpopo Province consisting of organizations responsible for epidemic prediction, issuing epidemic/alerting information and implementing countermeasures based on such information.	● The Project has commenced discussions among Japanese and South African research institutes in October 2015 for the establishment of a preparatory committee for introducing the climate prediction-based iDEWS. The Project held 2nd meeting in April 2016 to discuss the details of the committee and determined the Terms of References (TOR) of the Committee and nominated core members and external supporters. ● A preparatory committee for iDEWS introduction was formally established in January 2017. Participating organizations of the committee in the South Africa side include the LDOH, the National Department of Health (NDOH), the SAMRC, the CSIR, the SAWS and the NICD. Japanese researchers also participated the committee as advisory members. A total of four preparatory committees for iDEWS introduction have been held by the time of the Final Evaluation. The Second Preparatory Committee in July 2017 discussed the roles of each member agency and future plans, and the Third Preparatory Committee in September 2017 discussed a plan of pilot application of the climate-based malaria epidemic prediction model for malaria control in the Limpopo Province. The fourth preparatory committee in March 2018 discussed the reporting of forecast results in the 2018/2019 season as well as the response, countermeasures, etc. based on the forecast results, etc.
2-2. To set criteria for outbreak alerting.	● The preparatory committee for iDEWS introduction was held in the Limpopo Province to develop operational guidelines, including methods of transmitting information on malaria epidemic prediction (including outbreak warnings) and setting standards for disseminating forecast information. Initially, it was assumed to implement outbreak prevention through the issuance of alert information based on the early detection of a malaria outbreak and early containment response measures. However, when considering the characteristics of the malaria epidemic prediction models and its operation in the Limpopo province, where the number of malaria cases is rather small, compared with malaria high invasive countries such as Mozambique, the parties concerned agree not to issue individual outbreak alert information but to regularly announce epidemic prediction information and to take actions in accordance with operational guidelines, etc. ● Although it is technically possible to provide estimates of the malaria epidemic as a number of cases, the iDEWS preparatory committee decided to announce alerting by grading the risk level based on the number of patients in a certain time period in the past, since recipients' risk judgement can be subjective given that there is no comparator even if the actual number of patients is announced. Specifically, the forecast information based on a nonlinear statistical model, of which alert levels are '*low*', '*medium*', '*moderately high*' and '*high*' on the basis of the average number of patients in the past malaria epidemic season from September to May, is announced on a weekly basis for the following 16 weeks. On the other hand, the forecast information based on machine learning are supposed to be announced on a monthly basis throughout the year for the following three months on a quarterly basis. The alert levels are determined by grading the risk by six levels (levels 1-6) on the basis of the average number of patients in each month in the past. ● As the characteristics of these two malaria prediction models, the nonlinear statistical model has high prediction accuracy in the near term, because the prediction calculation is carried out in weekly unit. Especially, the accuracy of the epidemic prediction in the malaria epidemic season is high. On the other hand, a prediction model based on machine learning has characteristic features as follows: it is possible to predict monthly over one year; and the accuracy of long-term forecasting is higher than that based on the statistical model. Therefore, it is considered that more appropriate prediction judgment is possible by examining the forecast results in consideration of the said characteristics of the two models.

2-3. To set communication flow of infectious diseases epidemic/outbreak information in the Limpopo Province.	● Legal considerations revealed that the Project was obligated to use existing and official systems of issuing warnings and dissemination of predictions. Hence the NICD and the SAWS were recruited into the Project in the initial phase of the cooperation period since this is their legal and mandated function. The iDEWS Bureau will conduct their work under the auspices of the NICD and the SAWS, which will forthwith have the responsibility of conducting this function via their official channel. ● The preparatory committee meetings for introducing the iDEWS have been held in the Limpopo Province 4 times in total as of the time of the Final Evaluation, and procedures for a pilot implementation of the countermeasure against malaria epidemic based on the forecast result as well as the setting of necessary forms and norms such as the standard and method of announcing (including the outbreak warning) were discussed. ● Forecast information is sent by e-mail to relevant organizations as informal and testing phase, on a monthly basis in general. In January 2018, the Project held a workshop for a total of 30 staff engaged in malaria control in the Limpopo Province for sharing of forecast and discussed the practical use of forecast information on upcoming malaria seasonal epidemics in 2018. ● NEKKEN developed an application in which the prediction data can be visually referenced on the web as a prototype. The development work is largely completed from a technical point of view, and forecast information is designed to be automatically updated to the app. The scope of publication will continue to be discussed amongst the member organization hereafter.
2-4. To develop an iDEWS operational Guidelines comprising regular reporting of epidemics, issuing outbreak alerting and consequent countermeasures, organogram of iDEWS operation, formats of regular reporting and alerting, etc.	● See the Activity 3-3 for the information of the development of iDEWS operational guidelines.

Output 3 Prediction performance and operability of the iDEWS are verified.	
Activities	Performances
3-1. To evaluate the prediction performance and operability of the iDEWS through a pilot application at the Limpopo Province. 3-2. To conduct table-top exercises regarding issuing outbreak alerting and consequent countermeasures at the Limpopo Province.	● Retrospective predictions of the 2016/2017 epidemic season, which became the first relatively large epidemic in about 20 years, were performed by the non-linear statistical model of NEKKEN as well as the machine-learning-based model of JAMSTEC, resulting that the values predicted by both models and that actually-observed were highly correlated; consequently, the member organizations of the Project deemed that both models were likely to have reached sufficient levels for practical application to the services. ● With this result, the Limpopo Provincial Government requested the Project to provide epidemic forecast information during the 2017/2018 malaria epidemic season. Therefore, the Project decided not to conduct desk-top training but to perform pilot application of forecast information from the climate-based malaria epidemic prediction models to measures for malaria prevention and control. Then, the Project examined and discussed methods of implementing measures, methods of communicating information, extent of information sharing, etc., and implemented intervention activities such as implementing a second IRS for hotspots predicted and raising awareness of residents at the initiative of the LDOH. Preliminary analyses on the said intervention based on the forecast information showed that a possibility that the intervention might have reduced the mortality of malaria infection; moreover, the actual number of malaria cases was slightly smaller than that predicted. The reduction of the reported cases and its related mortality might be attributed to the improvement of residents' awareness to malaria prevention as well as the environment of malaria diagnosis and treatment at health facilities. However, it is difficult for the Project to verify the effect of prediction information-based interventions such as additional IRS at hot spots as well as the information sharing with environmental health

	practitioners (EHPs) at this point; further, the migration of persons with malaria infection from neighbouring countries, the acquisition of resistance against the drug used for IRS by vector mosquito, and many alternative factors should be taken into consideration for analysing the intervention effects hereafter.
3-3. To develop a sustainable monitoring and evaluation system for assessing impacts of the iDEWS on infection control at the Limpopo Province.	● As just described above, it was confirmed that there is a need to continue discussions with more scientific perspectives on what and how interventions are implemented based on prediction results. South Africa had declared an intention for the establishment the "*iDEWS Bureau*" with technical assistance from Japanese research institutes (NEKKEN and JAMSTEC). The Bureau is expected to build evidences on the effectiveness of malaria control measures based on climate-based malaria epidemic prediction, and to continue to develop forms and norms such as practical operational guidelines, formats, etc. even following the project period ends.
3-4. To verify the applicability of other areas using available data of epidemics, climate and non-climate environment at other provinces of the South Africa and neighbouring countries.	● The SINTEX-F2 developed by JAMSTEC is capable of climatically predicting not only the Limpopo province but also more wider areas of southern African regions including Mozambique and Zimbabwe accurately. The Project was already received malaria epidemic data from the authority concerned of Mozambique, and verified the performance of two completed models for the prediction in the southern part of Mozambique. As a result, it is confirmed that both models can predict malaria epidemics in southern Mozambique with sufficient accuracy. The Japanese research institutes plan to maintain and further develop cooperation and joint research with related organizations in Mozambique even after the completion of the project period. ● On the other hand, the "*Southern Africa Malaria Elimination 8 Initiative*" (hereinafter referred to as "*Elimination 8*") [11]established in 2007 by eight Southern African countries for malaria elimination under the Southern African Development Community (SADC) has shown great interest in the application of climate-based malaria epidemic prediction to its member countries, and consultations on specific ways of collaboration have been initiated as of the time of the Final Evaluation. If cooperation with other Southern African countries can be initiated through Elimination 8, it is likely that the said models can be disseminated to those countries by fine-tuning them using malaria epidemic data in each country. ● Meanwhile, though non-climatic environmental data has not been used for verifying the applicability of the iDEWS, it can be used when considering measures based on forecast information.
3-5. To hold workshop(s) geared to administrative officers, researchers, etc. in the areas of climate variability and infection control from the government of the South Africa and neighbouring countries for the deployment of iDEWS.	● The Project held following symposia and workshops in South Africa or Japan as of the time of the Mid-term Review: ● Symposium and workshops hosted by the project including kick-off symposium, research symposium and research workshops: August 2014 in Pretoria with 42 participants, January 2015 in Nagasaki with 50 participants, October 2015 in Pretoria with 32 participants and November 2018 in Tokyo and Yokohama with 75 participants. ● Workshops at Tzaneen Malaria Institute for officers of the institute, Environmental Health Practitioner (EHP), medical facility employees in Limpopo to report the seasonal outlook of malaria: October 2014 with 32 participants, January 2018 with 26 participants, June 2018 with 30 participants and January 2019 with 15 participants. ● The iDEWS Lecture Series for master's students in South Africa : October 2015 (3days) with 66 participants and March 2018 (2days) with 50 participants. ● Meetings and workshops for the future collaboration with neighboring countries: January 2015 (SADC), September 2016 (officers with Mozambique embassy), April 2017 (SADC)
3-6. To start discussions with administrative officers, researchers, etc. in the areas of climate variability and infection control of the government of the	● The malaria epidemic prediction models based on climate forecasting developed in the Project showed high predictive performance, and pilot implementation of predictive information-based countermeasure activities conducted during the 2017/2018 epidemic season indicated that these models may have reached sufficient level for practical use. Based on these

[11] The "*Elimination 8*" is a coordinated and eight-country effort to achieve the historic goal of eliminating malaria in four southern African countries by 2020 (Botswana, Namibia, South Africa and Swaziland), and to subsequently pave the way for elimination in four more by 2030 (Angola, Mozambique, Zambia And Zimbabwe).

South Africa for the dissemination of iDEWS.	successful results, a declaration was agreed to the establishment of a "*iDEWS Bureau*" by relevant organizations including the iDEWS preparatory committee (the implementation organizations: NICD; SAWS; CSIR; SAMRC; UP; and LDOH, as well as the cooperative organizations: DST; ACCESS; and NDOH), of which major purpose will be to produce and disseminate periodic infectious disease outlook bulletins emanating from the information on the prediction of the epidemic of infectious diseases including malaria (signed ceremony was implemented in Tokyo on 15 November 2018) (Annex 6). ● The Japanese implementing organizations of the Project, NEKKEN and JAMSTEC, showed a willingness to continue technical assistance to the iDEWS Bureau even following the Project has ended. The declaration has been witness-signed with the said two Japanese research institutes and also JICA.

2) Achievements of the Outputs

a) Output 1

Achievements of the Output 1 are as indicated below.

【Output 1】

Climate-based infectious disease epidemic prediction models are developed especially for malaria, pneumonia and diarrhoea.

OVIs	Achievements
1-1. The iDEWS is developed with the prediction performance of a likelihood of malaria outbreaks with 3-month lead-time. The likelihood will be based on a verification of at least 60% agreement between retrospective prediction and past observations of defined outbreaks by the time of the Final Evaluation.	● The Project has succeeded in developing the climate forecasting-based malaria epidemic prediction models with sufficient prediction accuracy and certain length of lead-times for practical application for malaria prevention and control measures. ● The non-linear statistical model-based malaria epidemic prediction model, developed by NEKKEN, demonstrated over 0.7 of correlation coefficient between the predicted and actual number of malaria incidence; further, that in near-term of 4 weeks demonstrated 0.8 or more notably. ● The machine-learning-based model for predicting malaria epidemic, developed by JAMSTEC, has achieved high performance skill for all districts during the malaria epidemic season (September - May) with an average ROCAUC score of 0.712. ● The UP had developed the linear statistical model-based malaria epidemic prediction model, providing a prediction of entire 3-month malaria epidemic season from January to March in November (1-month lead-time) with high accuracy, demonstrated that the correlation coefficient between the predicted and actual number of malaria cases was as high as 0.8. ● The best performing models are combined to produce an ensemble model to predict monthly malaria outbreak probability with up to 3 months lead-time for each district of the Limpopo Province. ● Although it is difficult to express prediction performance in agreement between predicted and observed values as set in the OVI, both nonlinear statistical model and the machine-learning-based malaria epidemic prediction models developed in the Project can be evaluated as having sufficient level of performance for practical application, since correlation coefficients and ROCAUC scores as described above can generally be understood to be high performance if they are above 0.7.
1-2. The pneumonia prediction is prepared for potential use in early warning with 3-month lead-time. The prediction of seasonal variation will be based on a verification of at least 60% agreement between retrospective prediction and past observations by the time of the Final Evaluation.	● As was described in the Activity 1-3-2, the weather variables correlated with the number of patients for pneumonia are only temperature, and it is technically difficult to predict the diurnal temperature range; therefore, it has become clear that the development of climate-based epidemic prediction models for pneumonia is difficult at present.
1-3. The diarrhoea prediction is prepared for potential use in	● The Project identified the significant correlation of the number of diarrhoea cases with climatic variables as well as climate phenomena.

early warning with 3-month lead-time. The prediction of seasonal variation will be based on a verification of at least 60% agreement between retrospective prediction and past observations by the time of the Final Evaluation.	Prediction models for diarrhoea incidences are supposed to be verified and fine-tuned using retrospective data once trial models are developed. ● Project, nevertheless, has just commenced a preliminary examination for the development of endemic prediction models at present; thus, it is anticipated that those development works will not have completed within the project period (the 11th of March 2019 is the due date). ● The Having said that both the South African and the Japanese member organizations have presented clear intention for the continuation of joint work under the iDEWS Bureau (the details will be described later) even following the termination of the Project.
1-4. More than 4 research papers first and/or co-authored by both Japan and South Africa collaborators related to iDEWS, infectious disease mathematical and statistical models, short-term climate variability prediction system, relationship between climate variability and infectious diseases are published in peer-reviewed internationally recognized journals.	● As of the time of the final evaluation, the Project has published as many as 30 articles for climatology research, 10 articles for infectious disease outbreak research and 4 articles for health-related research in total in peer-reviewed international journals. ● As of the time of the Terminal Evaluation, several research articles concerning the infectious disease epidemic prediction are being drafted.

During the 1st half of the project period, JAMSTEC, with the support of the CSIR, had succeeded in developing a novel seasonal prediction system based on an ocean-atmosphere coupled general circulation model called SINTEX-F2 with higher resolution, which was developed on the basis of SINTEX-F by taking Antarctic sea ice into consideration. Owing to this improvement, the climate in neighbouring high malaria endemic countries such as Mozambique and Zimbabwe can be forecasted accurately. The SINTEX-F2 improved its prediction accuracy in southern Africa significantly. Moreover, JAMSTEC had succeeded in downscaling of global seasonal forecasting into local-scale prediction covering as narrow as approx. $10km^2$. Meanwhile, the UP had succeeded in developing an individualistic ensemble climate forecast model and subsequent downscaling. Each research outcome is published in international Journals as of the time of the Final Evaluation.

Concerning malaria, the Project has developed two epidemic prediction models on the basis of the non-linear statistical model and the machine-learning-based model, and both of which have demonstrated sufficient prediction performance enough to apply the prediction results to practical malaria prevention and control measures as shown in the Activity 1-1. Those models have succeeded in predicting relatively large malaria epidemic for the first time in 20 years in the 2016/2017 season retrospectively; subsequently, have also succeeded in predicting the magnitude of malaria epidemic in the 2017/2018 season, same as that in the previous season, prospectively. Further, the Project made prediction of the magnitude of malaria epidemic in this season (2018/2019), and found that the number of malaria reported cases as of January 2019 when the Final Evaluation is being performed is close to

Table 1 Characteristics of the Project's climate forecast-based infectious disease epidemic prediction models as of January 2019

Developpers		Climate Forecasting			Infectious Disease Epidemic Prediction		Prediction Performance		
		Global Climate Prediction Model	Method	Downscaling	Theory	Method	Lead-time	Prediction Duration	Practical Application
Japan	JAMSTEC	SINTEX-F2	108-member-ensamble prediction	OK	Machine-learning-based model	-	16 weeks	4 weeks	OK
	JAMSTEC	SINTEX-F2	108-member-ensamble prediction	OK	Mathematical model	VECTRI model	Under examination		Not yet
	NEKKEN	SINTEX-F2	Non-ensamble prediction	OK	Statistical model	Non-linear model	12 weeks	1 week	OK
South Africa	UP	North American Multi-Model Ensamble	Ensamble prediction	OK	Statistical model	Linear model	4 weeks	12 weeks	OK
	UWC	SAWS observational data	Under examination	N/A	Mathematical model	Compartmental model	Under examination		Not yet

that of predicted. The UP also has developed a statistical malaria epidemic prediction model, based on an ensemble climate forecast, with sufficient prediction performance for practical use. In parallel, JAMSTEC and the UWC have been working on the development of a mathematical model-based malaria epidemic prediction model individually. Though those two mathematical models have not reached a sufficient level for practical application to countermeasures at this point, both JAMSTEC and the UWC are anticipated to continue the development work even following the completion of the Project. The Table 1 shows the characteristics of the climate forecast-based malaria epidemic prediction models.

As for the development of diarrhoea epidemic prediction model on the basis of climate forecasting, it took longer-than-expected time and efforts to construct a database in the initial phase of the project period, and the Project has just commenced examination and discussions for developing models as of the time of the Final Evaluation. Having said that, the Project has already found links among number of diarrhoea cases and several climatic variables, as well as climate phenomena, implying that the climate forecast-based epidemic prediction modelling can be applicable to diarrhoea. Though it can be impossible for the Project to complete the developing work for diarrhoea epidemic prediction models with sufficient prediction performance for practical use by the end of the project period (May 2019), both South African and Japanese research institutes expressed the intention to continue the developing work even after the end of project period. Meanwhile, the Project found that the number of patients with pneumonia correlated with only one climatic variable of temperature though a seasonality in the number of pneumonia patients was found; consequently, the Project has judged that it is difficult to advance the research activities for the development of the models for pneumonia at this point. In other words, however, it can be said that the Project has elicited a sort of evidence that pneumonia is not applicable to the development of an epidemic prediction model based on the climate forecasting from a scientific point of view, and this experience of trial and error can be beneficially utilized as a basic tip for considering the application of the climate forecast-based epidemic prediction models to other infectious diseases. Thus, the Project could not develop a model for pneumonia at this time but gained important findings and experiences for developing a climate forecast-based epidemic prediction models for infectious diseases.

As of the time of the Final Evaluation, the Project has published a total of 44 academic papers. Thirty (30) of them are related to climatological research and in addition to those directly related to the Project, such as enhancing the precision of the seasonal climate forecasting systems and subsequent downscaling, the Project has also academically gained with interesting findings, such as demonstrating skills not only the seasonal and inter-annual variations in precipitation of the southern African region but also the slow fluctuation in the climate on a decadal scale. Following the Mid-term Review when the climate prediction technology had been established, full-scale research activities had been commenced for the development of models for predicting epidemics of infectious diseases based on climate forecasting. As mentioned above, the Project has completed the development work for 3 climate forecast-based malaria epidemic prediction models with sufficient prediction performance to apply them in practical prevention and control measures as of the time of the Final Evaluation. Though 14 scientific papers related to health sciences including the infectious diseases have been published, a number of relevant research results are anticipated to be gained and expected to be published in international journals hereafter.

Thus, as for malaria, two epidemic prediction models based on climate forecasting demonstrated sufficient epidemic prediction performance enough to apply them to practical prevention and control measures. The prospect of developing models for diarrhoea is also obtained, and the development work will be surely continued under the iDEWS Bureau. Though it became clear that the model development was technically difficult on pneumonia, it can be said that important experience and knowledge were given for the future research activity. For these reasons, the Output 1 seemed to have generally achieved its objective from the viewpoint of the technical cooperation.

b) Output 2

Achievements of the Output 2 are as indicated below.

【Output 2】 Operational guidelines of the climate prediction-based infectious diseases early warning system (iDEWS) are developed in the Limpopo Province.	
OVIs	Achievements
2-1. The preparatory committee for iDEWS operation is launched at the Limpopo Province by the time of the Mid-term Review.	● A preparatory committee for iDEWS introduction was formally established in January 2017. Participating organizations of the committee in the South Africa side include the LDOH, the NDOH, the SAMRC, the CSIR, the SAWS and the NICD. Japanese researchers also participated the committee as advisory members. ● The preparatory committee meetings for introducing the iDEWS have been held in the Limpopo Province 4 times in total as of the time of the Final Evaluation, and procedures for a pilot implementation of the countermeasure against malaria epidemic based on the forecast result as well as the setting of necessary forms and norms such as the standard and method of announcing (including the outbreak warning) were discussed.
2-2. The iDEWS operational guidelines is considered by authority/-ies concerned by October 2017.	● From these results, it is judged that the member organizations of the iDEWS Bureau should earn experiences for at least a couple of years in order to determine effective operational guidelines for applying the forecast information to practical measures for the prevention and control of malaria. ● Having said that, the relevant organisations including the members of the iDEWS preparatory committee highly evaluated the climate forecasting-based malaria epidemic prediction models for achieving the sufficient level of skills in the practical application of the forecast information to the prevention and control of malaria, and took practical actions to establish the iDEWS Bureau as of the time of the Final Evaluation. ● Therefore, it is anticipated that the operational guidelines are anticipated to be carefully developed on the basis of sufficient discussions.

Concerning the standards for disseminating forecast information, it was initially assumed to implement outbreak prevention through the issuance of alert information based on the early detection of a malaria outbreak and early containment response measures. However, when considering the characteristics of the malaria epidemic prediction models and its operation in the Limpopo province, where the number of malaria cases is rather small, compared with malaria high invasive countries such as Mozambique, the parties concerned agree not to issue individual outbreak alert information but to regularly announce epidemic prediction information and to take actions in accordance with operational guidelines, etc. The Project has succeeded in developing two malaria epidemic prediction models based on the non-linear statistical model and the machine-learning-based model, and is being examining the method for constructing malaria epidemic forecast information in consideration of its characteristics of prediction performance.

In addition, the preparatory committee for iDEWS operation, which was launched in January 2017, is not limited to research institutions, but involves national-level organizations such as NDOH, the SAWS and the NICD, which are key for future institutionalization, as well as the LDOH which are regarded as an actual user of prediction information on infectious disease epidemics. Under this preparatory committee, operational investigations were made, including validation of the predictive performance of malaria epidemics in the Limpopo province and the response (intervention) based on prediction results. As a result, all member organizations evaluated the predictive performance of climate forecast-based epidemic prediction models as practical levels, leading to consensus among the relevant organizations towards the establishment of the iDEWS Bureau. Since the abovementioned pilot study confirmed the need for further experience in order to develop operational guidelines, its developing work cannot be completed within the project period; nevertheless, the verification of ideal operation is likely to be carried out steadily under the iDEWS Bureau.

In conclusion, the objectives of the Output 2 are considered to have been met, as well as well-experienced and evidence-based iDEWS operation guidelines are expected to be completed steadily within the first few years after the completion of the project period.

c) Output 3

Achievements of the Output 3 are as indicated below.

【Output 3】 Prediction performance and operability of the iDEWS are verified.	
OVIs	Achievements
3-1. Prediction performance and operability of the iDEWS are evaluated by a pilot application at the Limpopo Province by May 2018.	● On the basis of the success of retrospective prediction of the number of malaria cases in previous epidemic season of 2016/2017, the Project, according to the request from the local government of the Limpopo province, provided forecast information of malaria epidemic in the upcoming 2017/2018 season. The Project discussed and examined the methods for announcing the forecast information as well as the scope of information sharing in applying the information to practical measures for the prevention and control of malaria. ● The LDOH, based on the forecast information, conducted interventions such as the additional IRS to the hotspot of malaria infection where predicted as well as the awareness-raising activities geared to community residents. As the results, the possibility that the interventions might have reduced the number of reported malaria cases and its mortality. However, it is required for the Project to verify the intervention effect from a scientific point of view.
3-2. Adaptability of the iDEWS to other areas including other provinces and neighbouring countries is presented to appropriate authorities by February 2019.	● During the 2016/2017 and the 2017/2018 epidemic seasons, epidemics also occurred in neighbouring countries adjacent to South Africa. The Project applied the climate forecast-based malaria epidemic prediction models developed in South Africa to Mozambique, of which malaria incidence data was provided to the Project; as a result, those models demonstrated sufficient prediction performance even in Mozambique. These results are shared with national organizations such as the NDOH and the NICD, members of the iDEWS preparatory Committee, and are also shared with Mozambique agencies concerned through individual contacts, workshops, and conference opportunities. ● Malaria patient information across South Africa has also been accumulated in iDEWS-dedicated databases, providing a basis for assessing adaptability to other regions in South Africa as well. Furthermore, given that the cooperation with Southern African countries can be initiated through Elimination 8, it is likely that climate forecast-based epidemic prediction models can greatly be expanded to the member countries of the Elimination 8 by collecting and applying the national malaria epidemic data at each country.

As mentioned above, the Project confirmed that the epidemic prediction models could predict the number of malaria cases in the 2016/2017 epidemic season when a large epidemic occurred for the first time in 20 years with high accuracy; based on this result, the prediction information from the models was practically applied to malaria prevention and control measures in the Limpopo province in the following season of 2017/2018. The results showed that the intervention may have affected the reduction of malaria mortality as well as slight decrease in the number of reported cases. However, it is considered that further detailed analyses should be needed for verifying the effect of prediction information-based preventive measures (interventions) by taking various alternative factors such as the migration of malaria carriers from neighbouring countries and so on into consideration.

From these results, it is judged that the member organizations of the iDEWS Bureau should earn experiences for at least a couple of years in order to determine effective operational guidelines for applying the forecast information to practical measures for the prevention and control of malaria. Having said that, the relevant organizations including the member of the iDEWS preparatory committee highly evaluated the climate forecasting-based malaria epidemic prediction models as achieving the sufficient level for the practical application of the forecast information to the prevention and control of malaria, and took practical actions to establish the iDEWS Bureau as of the time of the Final Evaluation. Therefore, it is anticipated that the operational guidelines are anticipated to be carefully developed on the basis of sufficient discussions.

The correlation between the epidemic and climatic variables and climatic events was also confirmed for pneumonia, and at the time of the Final Evaluation, the Project has just commenced the examination and discussions for the development of prediction models practically. Therefore, it is not possible to assess the predictive performance and operability in pneumonia control within the project period, but it is likely that the developing work will be continued under the iDEWS Bureau once the model is developed.

In conclusion, the model's predictive performance and operability are expected to be verified under the iDEWS Bureau and the development work is steadily completed within a few years after the end of the project period; thus, it is deemed that the objectives of the Output 3 are generally considered to have been met.

3) Achievements of the Project Purpose

【Project Purpose】 A climate-based early-warning system model for infectious diseases control is established as a precursor for further application across southern Africa.	
OVIs	Achievements
1. The iDEWS, the installation guide, the operational guidelines, operational costs, etc. are packaged as a precursor model for disseminating to other areas by the end of the project period.	● For two years following the completion of the Project, the iDEWS Bureau is supposed to be operated as a joint venture by the implementing organizations of the South African side, and the construction of evidences for the effectiveness of the application of the climate-based epidemic prediction models to practical malaria prevention and control as well as the development of operational guidelines will be conducted under the iDEWS Bureau. Thereafter, the member organizations are aiming that the iDEWS Bureau is incorporated into a public system in South Africa through consultation with relevant governmental organization. ● For malaria, preventive measures based on prediction information were piloted during the 2017/2018 epidemic season, suggesting the need to continuously implement operational improvements for better utilization of prediction information. Therefore, the optimization of operational guidelines is expected to continue under the iDEWS Bureau after the completion of the project period. At the final stage of the optimization work, cost analyses for new introduction and normal operation as well as packaging of necessary elements for deployment to other regions will be carried out. ● As soon as the verification of the epidemic prediction models are completed for diarrhoea operational, cost-analysis, and packaging are expected to be implemented under the iDEWS Bureau in a manner similar to that for malaria.
2. The iDEWS is presented to relevant South African authorities as a tool by the end of the project period.	● The said committee includes South African authorities in charge of weather/climate research and services such as the SAWS, CSIR and ACCESS, and they are considering the application of climate forecasting information to other sectors (e.g., agriculture and disaster preparedness) where high precision and downscaling have been achieved, and the iDEWS Bureau is expected to be used as a foundation for its implementation.

Efforts made by both Japanese and South African research institutes and administrative bodies have improved the accuracy of the seasonal climate prediction systems in the southern African region and led to successful downscaling. Based on this result, the Project has developed three malaria epidemic prediction models with practical-level prediction performance, and actual preventive measures based on prediction information are piloted, and the effects and problems are confirmed. South African research institutes and administrative agencies highly appreciated project's achievements and have agreed the intention to establish the iDEWS Bureau to make a climate-forecast-based infectious disease epidemic prediction service, especially for malaria, as a part of administrative services in future. In addition, the climatological and infectious disease research groups of the project's research institutes have started the joint research with the Mozambican authorities concerned as of the time of the Final Evaluation, and the prediction performance of the models will further be improved hereafter. In addition, the cooperation with the Elimination 8 is becoming concrete on the malaria, and the expansion to the southern African region is also greatly expected. Although the modeling of diarrhoea has not been achieved due to the delay in the first half of the project period, the development work is supposed to continue under the iDEWS Bureau. Although it has been confirmed that it is technically difficult to develop epidemic prediction models based on climate variation prediction for pneumonia, the process to judge it may have provided an important basis for consideration of its application to other diseases.

Through these activities, a number of scientific findings and research results were obtained on climate prediction and infectious disease epidemic prediction. Many academic papers have been published in international journals, especially from research on climate prediction, which was main research activities in the 1st half of the project period. Findings and research results on the development of a model for predicting epidemics of infectious diseases and its application to actual preventive measures have also been created in the latter half of the project period, and are expected to be published as many academic papers even following the end of the project period.

On the other hand, the South African research institutes have already had certain research capabilities by the time of commencing the Project. Therefore, rather than providing "*technical transfer*" from the Japanese side conducted with that in developing countries, the South African research institutes are expected to improve their research capabilities by carrying out technology exchange with Japanese research institute at a high level as equal partners, and the formation of a platform where members with various research fields and organizational functions (e.g., research, administration, services) cooperate each other is expected to have a synergistic effect at a high level in future.

Thus, the establishment of an early warning system model based on climate forecasting for controlling infectious diseases as the first step towards its application to Southern Africa countries (the Project Purpose) is likely to be steadily achievable within a few years. As mentioned above, significant achievements were confirmed both from the academic perspective and from the perspective of ODA technical cooperation. Besides, the current-observable issues have been appropriately organized. For these reasons, it is deemed that the Project can be regarded as largely achieving its objectives as of the time of the Final Evaluation.

3.3 Implementation Process

1) Project Management and communication among parties concerned

As a result of re-examination of the research institutes of the South African side that are required for actual joint research, the NICD, the SAWS, the UP, and the UV were added to the list of institutes for implementation of the Project and the National Institute of Disaster Management Centre of South Africa and the Kyushu University participated as external cooperative institutes by the time of the Mid-term Review. As the result, a total of 17 institutes participated for the implementation of the

Project including the external cooperative institutes, comprising 14 institutes from South Africa and 3 institutes from Japan.

The Project has an impressively high number of participating institutes among the SATREPS projects in infectious disease fields, making communication adjustments difficult. However, cooperation relationship is maintained within the climate research groups in particular as a result of the previous SATREPS projects and smooth communication is maintained throughout the project period within the infection disease research groups thorough communication adjustment management of project coordinators (JICA experts) who is stationed in Pretoria and a Japanese researcher (JICA expert) stationed in the Limpopo province. The South African project member organizations vary greatly such as research / government agencies, climate / infectious disease research, and national / field levels; nevertheless, a project manager of ACCESS/CSIR has been organizing very well the agencies involved, and communication and coordination with the Japanese parties were smoothly carried out. The JICA South Africa Office also actively supported project management. Therefore, it is considered that proper project management has been implemented throughout the project period.

2) Ownership and autonomy

As has been described, the project member organization of the South African side highly evaluated the achievements of the Project; consequently, declared an intention of the establishment of the iDEWS Bureau. The Bureau is expected to play an important role not only to apply the project's achievements to the prevention and control of infectious diseases practically, but also to promote the dissemination it to other provinces and even southern African countries as well as to apply it to another field independently. The South African side has already commenced practical activities for the establishment of the iDEWS Bureau and the dissemination of the project's achievements. For these reasons, it is deemed that both ownership and autonomy of the South African member organization to the Project is significantly high.

CHAPTER 4 EVALUATION RESULTS

4.1 Relevance

The relevance of the Project has been highly maintained hitherto.

1) Consistency of the Project Purpose with the South African Health Policies and the needs of target groups

In Southern African countries including South Africa, infectious diseases are major threats. Though under-5 mortality of diarrhoea and pneumonia are being reduced in recent years, those two diseases are still being regarded as major under-5 causes of death in South Africa (8.7% and 16.9%, respectively in 2015) in South Africa[12].

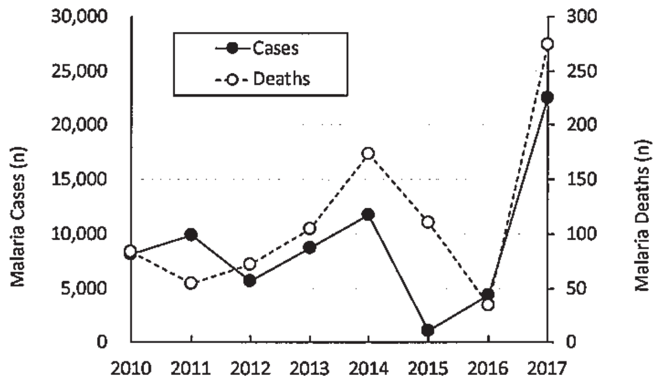

Figure 1: Reported Malaria Cases and Deaths in South Africa

Malaria is well controlled in comparison to other Southern African countries. However, the Northeast regions of South Africa sharing the borders with malaria endemic countries such as Mozambique and Zimbabwe including the Limpopo province, which is the target region of the Project, are especially exposed to malaria infection risks. Actually, as shown in the Figure 1, in 2016, when the Mid-term review was conducted, the number of reported malaria cases was thought to be at a level close to elimination, with 4,323 cases and 34 deaths, while in 2017, a large malaria epidemic had occurred; in particular, the number of reported cases and deaths were 22,517 (more than 5 times higher than that in the previous year) and 264 (approximately 5 times higher), respectively. The following year of 2018 saw a similar magnitude of the epidemic; therefore, it is obvious that South Africa is still at risk for malaria. Under such conditions, the national DOH of South Africa positioned the reinforcement of infectious disease countermeasures as the "*Primary Medical Service*" of the national program in the "*Strategic Plan 2015-2020*". It promotes the strengthening of the infectious disease surveillance system and strengthening preparedness and core response capacities for public health emergencies in line with the International Health Regulations (IHR). The Government of South Africa stresses the implementation of the science and technology cooperation with Japan. The "*South Africa-Japan Cooperation in Science and Technology*" that was jointly announced by the DST of South Africa and the Japanese Embassy in South Africa stipulates the importance of JICA in the science and technology cooperation in South Africa and the role of SATREPS and also provides the introduction of the Project.

Based on the above, the consistency of the purpose of the Project that implements infectious disease countermeasures based on the technical enhancement of South African – Japan research institutes with the South African health policies, science and technology policies, and the needs from community residents in South Africa are enhanced further.

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[12] Quoted from 2015 United Nations estimations (UNICEF. Under 5 mortality: Current Status and Progress. New York: UNICEF, 2017. *https://data. unicef.org/topic/child-survival/under-five-mortality/*)

2) Consistency of the Project Purpose with Japan's Aid Policy

In the ODA policy in Japan also, infectious disease countermeasures are stressed and the "*Yokohama Action Plan 2013-2017*" that is the basis of the specific policy of the "*Yokohama Declaration 2013*" that was agreed in the 5th Tokyo International Conference on African Development (TICAD V) in June 2013 reviewed the importance of infectious diseases countermeasures and also indicates the importance of the approach towards climate change issues by many sectors. The "*Nairobi Declaration*" that was adopted in TICAD VI that was implemented in August 2016 confirmed that the "*Yokohama Declaration*" and "*Yokohama Action Plan*" are effective until the next TICAD in 2019.

In "*improvement of the standard of science and technology of Africa through human resource development*" and "*return of the results of research and development to the society*" in the proposal "*Rich Africa with the power of science and technology and innovation*" that was created by the science and technology adviser of the Minister for Foreign Affairs towards TICAD VI exactly match the idea of SATREPS. In this way, the Project matches the science and technology diplomatic strategy.

Therefore, there are high consistencies between the Project that aims at the establishment of the infectious disease early warning system based on the climate change prediction, the international health policies and the science and technology diplomatic strategy of Japan.

3) International requirements relating to the infectious disease countermeasures based on the climate change prediction

WHO clarifies the necessity for the countermeasures for the impact of climate change such as global warming on the health of people. In particular, "*WHO Global Programme on Climate Change & Health*" (2016) indicates the importance of obtaining the scientific basis relating to climate change and health. Therefore, the development of infectious disease epidemic prediction models based on the correlation between climate change and malaria, pneumonia, and diarrhoea and scientific analysis relating to the administrative handling based on the prediction information are also considered to meet such international demands.

Infectious disease epidemic prediction models based on climate and weather variables have been developed by many experts academically. However, there are hardly any research groups that are practically developing the models based on the "*forecast*" of climate other than the research groups of the Project. These research outcomes of the Project were presented in December 2018 at the Fall Meeting of the American Geophysical Union, a world-class authority, and are highly appreciated. Furthermore, indeed, examples of using the prediction information in the actual administrative systems. Establishment of infectious disease countermeasures and disaster countermeasures based on the highly accurate localized infectious disease epidemic prediction model within a period of several months would be the first example globally.

4) Appropriateness of implementation method

① Rational for implementing research on the development of iDEWS targeting "*Pneumonia*" and "*Diarrhoea*", both of which are not definitive diagnoses

"*Pneumonia*" is a disease presentation of inflammatory diseases in lung, of which cause can be an infection of pathogenic agents or be non-pathogenic reasons such as drug-induced pneumonia. Likewise, "*diarrhoea*" can be infectious or non-infectious. Pathogens include viruses, bacteria, fungi, etc. and each of which has various species, and naturally, preventive measures and treatment varies in accordance with causative agents. In other words, the cause of pneumonia as well as diarrhoea can be of great variety, and various factors can affect its onset. Besides, it is unlikely for diarrhoeal diseases except for cholera to cause outbreak at disaster level, and incidence of pneumonia or diarrhoea can be managed within the range of seasonal change usually. Under such conditions, the Japanese relevant persons concerned pointed out several questions as follows: whether how much a limited factor of the climate prediction information affect the incidence of pneumonia as well as diarrhoea; and whether it is necessary for the development of a system to determine administrative countermeasures based on the climate-based infectious diseases epidemic prediction results for pneumonia and diarrhoea which can be managed within the normal range of seasonal change.

Especially in the rural part of South Africa, it is usually difficult to obtain the information of definitive diagnoses, i.e., causative pathogens, but the name of disease group of "*pneumonia*" and "*diarrhoea*". The Project, nonetheless, observed certain correlations of the climatic variables and phenomena with the number of cases of the said disease groups of pneumonia and diarrhoea. Since the number of cases and even casualties of pneumonia and diarrhoea are significantly greater than that of malaria, it is of great needs for the LDOH, other administrative bodies and health facilities in the Limpopo province to receive prediction information of the incidence of pneumonia and diarrhoea in advance of occurrence, especially in remote and/or rural areas where the clinical care setting is much weaker than that in urban areas. Therefore, it is confirmed the rationale for the development of iDEWS for pneumonia as well as diarrhoea within the framework of the Project.

Though the Project found that it is inapplicable for pneumonia to develop a climate forecast-based epidemic prediction model from a technical viewpoint as of the time of the Final Evaluation, the Project has just commenced research activities for developing a model for diarrhoea. Having said that, it is still true that the prevention measures and treatment should be determined in accordance with the causative pathogens; therefore, the Project, at the initiative of the iDEWS Bureau, should carefully determine the definition of the name of disease group of "*pneumonia*" and "*diarrhoea*" and how the countermeasures should be taken on the basis of the infectious disease prediction information on the basis of the available evidences even following the end of the project period.

② Special consideration for gender issues, social grades, environment, ethnic groups, etc.

Since the Project does not involve direct handling of infectious substances as a part of the development of the warning system based on the epidemic prediction of malaria, diarrhoea, and pneumonia, no special consideration is required for the environment and health threats to the experts (researchers).

The technical capability of the research institutes of South Africa is comparatively high, however, the opportunities for the students of regional universities to experience cutting-edge research are restricted. In the Project, a lecture series targeting the students of the master's degree course was held and Limpopo was determined as the venue to enable the students of the UL and the UV, which is located near the border with Zimbabwe to participate in the lectures.

4.2 Effectiveness

The effectiveness of the Project is considered to be high.

1) Probability of Achievement of Project Purpose

As was described in the "*Achievement of the Project Purpose*" section, during the 1st half of the project period, JAMSTEC has succeeded in improving the forecasting skill of the seasonal climate prediction system and subsequent downscaling, and it can be said that the said system provides the climate forecast in the Southern African region with the highest accuracy in the world. As the effect of Antarctic sea ice on climate decreases with distance from South Africa to the north-eastern direction, it is technically feasible to provide climate forecast with high accuracy and a certain lead-time using current systems from South Africa until up to the area around the Republic of Kenya. On the South African side, the University of Pretoria has also developed its own ensemble climate prediction model, which is regarded to reach a sufficient level for practical use.

Following the time of the Mid-term Review, both South African and Japanese research group, in parallel, have been working on the development of climate forecast-based infectious disease epidemic prediction models by coupling the climate models with the infectious disease epidemic prediction models geared to malaria, diarrhoea and pneumonia.

As for malaria, JAMSTEC has completed the development of an epidemic prediction model based on machine learning technique and NEKKEN has also completed the development of a non-linear statistical model, both of which are coupled with climate projections provided by SINTEX-F2 in Japan. The University of Pretoria has also completed a linear statistical model to predict malaria epidemics based on its own ensemble climate projections as of the time of the Final Evaluation. Both models have been confirmed to possess sufficiently-high predictive performance for practical use. Both the non-linear statistical model based (NEKKEN) and the on the machine learning-based model (JAMSTEC), of which development works had been largely completed in 2017, had provided prediction information for the 2017/2018 malaria epidemic season based on the request from the Limpopo provincial government, and prediction information-based measures were taken for the prevention and control of malaria epidemics on a trial basis. The results suggested that the intervention for the prevention and control of malaria epidemics may have contributed to slight reduction in the number of malaria reported cases and its related deaths to a certain degree. However, the accurate understanding of these results requires scientific verification, and it is difficult to optimise preventive intervention methods for maximizing the use of prediction information in one trial in one epidemic season. It is believed that operational guidelines can be finalized by repeating the intervention studies based on the verification results for several years even after the completion of the project period. In order to optimise the operational guidelines, it is not only possible to consider the effects of interventions based on prediction information, but also taking into account available resources (human resources, budget, etc.) and local regulations concerning infection control in target areas such as the Limpopo province. Therefore, if needed, it is recommended for the iDEWS Bureau members to consider the possibility of collaborative research and/or operational partnership with and research groups or individual researchers with knowledge and experience of public health research.

On the other hand, for diarrhoea and pneumonia, more time and labour than was expected for database construction from paper-based hospital data, and the progress of related research activities afterwards were also affected. For diarrheal diseases, the Project found strong evidence for the role of temperature and precipitation in the analysis of the data available. This implies that the diarrhoeal disease is particularly sensitive to variation in precipitation (as temperature is more consistent) and so therefore, to drought conditions. Strong correlation with typical El Nino conditions (drier and warmer than average) were found and on this basis, the rationale for the development of climate forecast-based diarrhoeal disease epidemic prediction model is deemed to exist. Furthermore, the model developed by the Project has applicability for entire South Africa, i.e., the region where diarrhoeal disease is prevalent. The approach of using proxy data (drug sales and insurance claims) is relatively novel and a useful way of supplementing direct measures of incidence especially where data availability is constrained. This is regarded as one of significant findings and research results of the Project; however, the operationalisation of these results is still required to be examined and it is the stated intention of the project partners to pursue this aspect through the operations of the iDEWS Bureau.

The Project found that the number of patients with pneumonia correlated with only one climatic variable of temperature though a seasonality in the number of pneumonia patients was found;

consequently, the Project has judged that it is difficult to advance the research activities for the development of the models for pneumonia at this point. In another words, however, it can be said that the Project has elicited a sort of evidence that pneumonia is not applicable to the development of an epidemic prediction model based on the climate forecasting from a scientific point of view, and this experience of trial and error can be beneficially utilized as a basic tip for considering the application of the climate forecast-based epidemic prediction models to other infectious diseases. Thus, the Project could not develop a model for pneumonia at this time but gained important findings and experiences for developing a climate forecast-based epidemic prediction models for infectious diseases.

Meanwhile, as was described in the "*Achievement of the Output 1*" section, during the project period, a number of scientific papers on climatological research have been published in frontline international journals (a total of 44 papers as of the time of the Final Evaluation). Although only a few studies have been conducted on models for predicting epidemics of infectious diseases based on climate forecasts in other research groups, three models for predicting epidemics of malaria with different characteristics have been developed and confirmed to be at the practical level. Since the application of prediction information by these models to actual malaria prevention measures will be carried out followed by the verification of intervention effects from the scientific viewpoint, it is anticipated that many related research findings and outcomes are anticipated to be published in international journals even following the completion of the project period. On the other hand, unlike international joint research with other developing countries, the Project has been continuing technological cooperation and exchanges at a very high level as equal partners, challenging frontier sciences such as development of a model for predicting epidemics of infectious diseases based on climate forecasting, and practical application to the prevention and control of malaria epidemics. The Project commenced such a cross-cutting research with no experience and even record; however, gained many research findings and outcomes with high possibility to apply them to the society as of the time of the Final Evaluation. This is thought to have greatly improved the capabilities of relevant organisations such as research institutes in both South Africa and Japan, central and local administrative agencies and even health facilities in South Africa; thus, the Project could have produced significant achievements from the perspective of ODA assistance.

For these reasons, since the Project achieved a lot of scientific research outcomes as well as the enhancement of the capacity of research institutes and researchers, the effectiveness of the Project as of the time of the Final Evaluation is deemed to be significantly high from the academic point of view.

Though the Project could not complete to establish iDEWS for each of three target diseases, the achievement level of the Project from both academic and ODA points of view is significantly high; thus, it is deemed that the "Effectiveness" of the Project is high in general.

2) Important assumptions for the achievement of Outputs and Project Purpose

Current status of the important assumption of "*Necessary cooperation is gained by external project supporters (e.g. ARC and superintendents of public buildings, etc.) for the project activities*" for the achievement of Outputs

It was supposed that the terrestrial climate data will be provided by the ARC and the SAWS to the Project; nevertheless, the said data was not provided by the ARC. However, though it took longer-than-expected time, a contract for the provision of the terrestrial data from the SAWS was eventually concluded in August 2016; the said data has just become available for the Project. However, the terrestrial climate data were supposed to be used for the verification of the skill of the downscaled climate prediction; thus, this delay of the signing of the contract has less influence on the development of SINTEX-F2.

The SAWS and the NICD were placed as an external supporter at the initial phase of the Project, both of which become the project members at the time of the 2nd JCC held in October 2015 in consideration of the strengthening of the implementation system for the practical application of research findings and outcomes to the society as well as of enhancing the sustainability of the benefits of the Project.

3) Contributing Factors for Effectiveness

Many institutes including the implementation institutes participated in the Project. Frequent communications and discussions were held via e-mail and telephone within both the research groups that are engaged in the development of climate change prediction models and the groups that are engaged in the development of infectious disease epidemic prediction models. These are the factors for achieving smooth implementation of joint research in remote mode between South Africa and Japan and for acquiring the research results as described above. In addition, the Project strategically included two national organisations of the SAWS and the NICD, which leads to the reinforcement of the project implementation system for the practical application of project's achievements. It is considered that these enhanced the effectiveness of the Project.

4) Inhibitory Factors against Effectiveness

It was agreed that the computerization of paper-based inpatient hospital information followed by the construction of database would be done by the input from the South African side. The said works require a lot of labour force; thus, it was required for the South African side to allocate some budget to outsource. Unfortunately, the budget took longer-than-expected time to become available of the budget on the South African side.

This caused a certain delay in the project activities especially for the development of infectious disease epidemic prediction modelling for pneumonia and diarrhoea. The Project found, eventually, that pneumonia is technically inapplicable for the development of a climate forecast-based epidemic prediction model; however, the said delay has affected for the Project to develop a model for diarrhoea; consequently, the Project had just commenced the development work for it at the time of the Final Evaluation. For this reason, this can be recognized as a hindering factor to the effectiveness of the Project.

5) Others

After the commencement of the Project, the project members of the national DOH, the LDOH, and the CSIR left the project due to the job transfers. To maintain the collaborative relationship with the new members, some efforts and time were required from the Japanese project members. Although there were some replacements of the junior researchers of South Africa who have participated in the research activities of the project, the negative impact on the project activities was avoided by the effort of the project members.

4.3 Efficiency

The efficiency of the Project is moderate for following reasons.

1) Progress Management of the Project Activities

The MOU was exchanged between the South African side and the Japanese side in May 2014; nevertheless, two (2) long-term JICA experts (a researcher and a project coordinator) arrived at their positions in South Africa in October 2014, five (5) months after the commencement of the Project, which resulted in delays in the installation of research instruments as well as the commencement of data collection activities. Aside from this, it took longer-than-expected time for the South African project member organisations to enter into the MOU among them, which resulted in some delay in the acquisition of the terrestrial climate data.

As was described in the "*Effectiveness*" section, the budget allocated by the South African side for the construction of the database of hospital inpatient information became available eventually in 2016, resulted that the modelling work has lagged behind the schedule by 6-12 months; for this reason, the Project could not complete the epidemic prediction modelling for diarrhoea as of the time of the Final Evaluation.

Having said that, the South African and Japanese research institutes have continuously and frequently been communication each other through various channels such as JCC meetings, symposia held both in South Africa and Japan, day-to-day emailing and teleconferences as of the time of the Final Evaluation; for these reason, it is deemed that the management of the progress as well as the generation of research outcomes has generally been appropriate. This can be explained by the significant achievement of research outcomes of the Project as of the time of the Final Evaluation. Further, the causes of the delays are seemed to be external factors, and the South African side had been putting best effort to the Project by allocating their own budget for the project activities as well as working on the orchestrating the iDEWS preparatory committee. Therefore, it is considered that the project management itself has been appropriate in general throughout the project period.

2) Beneficial utilization of provided equipment and materials

The Project has been conducting research activities by utilizing existing research instruments in South Africa, but provided a minimum of instrument, equipment and devices to the South African member organisations. The installation of research instruments was almost completed as scheduled as of the time of the Mid-term Review.

Though the frequency of use varies in accordance with the related purpose and environment, all the instruments, equipment and devices are properly used to the research activities and maintained by the South African side.

3) Beneficial utilization of knowledge and skills acquired at the training in Japan

A total of seven (7) South African young researchers were dispatched to Japan for short-term training. The knowledge and skills gained through the trainings were utilized to the research activities including data collection and analyses directly or indirectly.

It is worth noting that a young researcher (meteorologist) was sent to JAMSTEC to acquire technologies regarding the application of climate forecast information from the SINTEX-F2 to the prediction of infectious diseases epidemics and the downscaling of predictions.

4) Collaboration with External Resources

① Collaborative development of latest malaria epidemic prediction model (VECTRI model)

The developer of the VECTRI model (an Italian researcher) provided its source code to the Japanese research institute, and they are collaboratively working on the improvement of the said model. The model is taking the ecology of malaria vector mosquito into consideration; thus, it was regarded as one of the most potential models of the project for malaria epidemic prediction as of the time of the Final Evaluation. The VECTRI model-based malaria epidemic prediction model, nevertheless, could not demonstrate sufficient prediction performance at this time. The Project, at the initiative of JAMSTEC, is supposed to continue to improve the model even following the end of the project period.

② Collaboration with the local NGO for the improvement of malaria surveillance system in the Limpopo province

For the effective operation of iDEWS as well as the performance verification of malaria epidemic prediction models, it is critical that malaria surveillance system is properly functioned, which provides original data and information to the prediction model. The Project was considering introducing an infectious disease reporting system using cell phone, which was well established by other SATREPS project in Kenya (NEKKEN is an implementer of the project), and invited a researcher from the Kenya SATREPS project to the symposium held in the Limpopo province to give some lecture regarding the reporting system.

However, the Project abandoned their attempt to introduce the said system in the Limpopo province to avoid duplication since a local NGO supported by the Clinton Foundation HIV/AIDS Initiative after the symposium. The Project and the NGO agreed to support each other for the improvement of malaria reporting system in the Limpopo province. In particular, after the operation the reporting system which was supported by the NGO, the malaria incidence information was shared with the TMI within 24 hours after diagnosis; owing to this, the TMI can start the active surveillance for asymptomatic malaria infection promptly by the time of the Mid-term Review.

5) Contributing Factors for Efficiency

As aforementioned, 12 South African research institutes are participating in the Project and are widely scattered in whole of South Africa such as Pretoria, Limpopo, Durban and Cape Town.

Under such situation, the JICA experts (both 1st and succeeding project Coordinator) stationed in South Africa and the Project Manager of the South African side helped each other to carry out liaison and coordination not only between South African and Japanese research institutes but also even among South African member organisations, and enjoyed the confidence of both South African and Japanese researchers. This is regarded as a contributing factor for the effectiveness of the Project from the aspect of the smooth implementation of the project activities.

6) Hindering Factors against Efficiency

At the time of the Mid-term Review, the Joint Review Team provided a recommendation to allocate a JICA expert with related expertise in order to conduct the prevention and control of malaria epidemics on the basis of the evidences in an effective and efficient manner; however, it was not realized. As a result, this might cause that ad hoc countermeasures with less evidences or discussions were taken for preventing epidemic of malaria in 2017/2018 season when a large-scale outbreak of malaria is predicted.

Though many factors might affect the unsuccess of effective allocation of a JICA expert based on the recommendation, it can be considered that this unsuccess hindered from maximizing activity results by effective allocation of necessary human resources. Therefore, this can be regarded as a hindering factor against the "*Efficiency*" of the Project.

4.4 Impact

The following positive impacts are confirmed and/or expected by the implementation of the Project.

1) Probability of achievement of envisaged Overall Goal(s)

The technical cooperation projects, implemented under the scheme of SATREPS, are not always required to set Overall Goal(s) due to its characteristic feature of "*joint research project*". Having said that, SATREPS Project puts greater emphasis on the practical utilization of research outcome of projects to society; therefore, the Project clearly describes the expression of "*as a precursor for further application across southern Africa*", and the climate-based iDEWS model(s) for better control of infectious diseases in southern Africa are expected to be applied by their self-help endeavour after the end of the project period.

Since many malaria cases are reported in bordering areas with Mozambique and Zimbabwe, the Project selected the Limpopo province as the project site. The Project found that the incidence of malaria in the Limpopo province has a positive correlation with the precipitation in the southern part of Mozambique and Zimbabwe with 3-month time lag. Further, it is suggested that a definite proportion of malaria cases reported in the Limpopo province is imported cases from neighbouring countries; therefore, it is desirable that the information of malaria incidence in those countries are provided to further improve the prediction skill of malaria epidemic prediction models. For these points of view, The Project has already started collaboration with the Ministry of Health and the Malaria Control Programme in Mozambique, and received data concerning malaria epidemic in Mozambique for previous 20 years. The climate forecasting models improved by the Project are already capable of forecasting climate in Mozambique, consequently, it is technically possible to perform malaria epidemic prediction using current climate forecast-based epidemic prediction models even now. Moreover, given that further support from the Mozambique were gained for the project research activities, the correlation between the ecological factors of the vector mosquito and malaria epidemics can be investigated, of which related findings can be used for fine-tuning the models.

On the other hand, the Elimination 8, established in 2007 by eight Southern African countries for malaria elimination under the SADC, has shown great interest in the application of climate-based malaria epidemic prediction to its member countries, and consultations on specific ways of collaboration have been initiated as of the time of the Final Evaluation. If cooperation with other Southern African countries can be initiated through Elimination 8, it is likely that the said models can be disseminated to those countries by fine-tuning them using malaria epidemic data in each country.

However, in order to realize the application of the iDEWS for malaria to other provinces in South Africa and even other countries, the Project should create individual evidence of the effect of each possible intervention based on the epidemic prediction for the prevention and control of malaria; subsequently, on the basis of those evidences, the Project is required to realize an optimization of operational guidelines in consideration of available resources such as human resources and budget. Furthermore, the Project should perform a scientific verification on the effect of interventions for the prevention and control of malaria taken in accordance with the optimised operational guidelines on the number of malaria cases and related casualties, and consequently, demonstrate a comprehensive evidence of the effectiveness of the malaria iDEWS. If these are all realized, the dissemination of the malaria iDEWS can be disseminated to other regions in South Africa and even neighbouring countries eventually.

2) Other Positive Impacts

① Relationship between the decadal change in the precipitation in southern Africa and the malaria incidence

As was shown in the Activity 1-2-3, the JAMTEC discovered the decadal change in the precipitation in southern Africa on top of annual or seasonal change from the analyses of meteorological observation data. Further, the analyses results using SINTEX-F2 demonstrated a strong correlative relationship between the said decadal change and other decadal change in sea surface temperature as well as pressure that moves eastward from the South Pacific Ocean to the South Indian Ocean.

Based on the said findings, the Project is working on the analyses using detailed retrospective data to investigate correlative relationship of the decadal climate change in southern Africa with the malaria incidence in South Africa as of the time of the Final Evaluation. If the Project succeeds in the relationship, the climate-based infectious disease epidemic prediction modelling as well as the practical administrative countermeasures are positively impacted by the evidence.

② Functional enhancement of the Tzaneen Malaria Institute

A JICA long-term expert (epidemiologist / medical entomologist), stationed in the Tzaneen Malaria Institute, has been working together with the staff member of the TMI on their daily duties as well as project research activities, resulting in the capacity enhancement of the institute as well as staff members through the installation of research instruments and related equipment with necessary research techniques.

In particular, the TMI, with the support of the Project, established a surveillance system of imaginal malaria vector mosquito in the Greater Giyani as a sentinel site. Though the capturing of mosquito and the maintenance of light traps are conducted by temporally-hired community residents, it is anticipated that the system is maintained by the TMI even after the end of the project period. Meanwhile, the surveillance of larval mosquito has been done by the TMI as its duty. The TMI staff members, with the support of the JICA expert (researcher), improved the implementation methods and developed or revised forms and norms such as an implementation manual, record forms and the Standard Operating Procedure(s) (SOPs). Furthermore, the JICA experts also assisted the TMI staff members to develop or revise the SOP and forms for the malaria active surveillance on human asymptomatic infection through the investigation on the residents encompassing the index cases.

③ Collaboration amongst crosscutting stakeholders on the development of iDEWS as a platform

In the development of iDEWS, an international collaborative study of research institutes in South Africa and Japan aims to academically develop models to predict epidemics of infectious diseases based on climate forecast, apply them to infection prevention and control measures on the ground, and ultimately establish them as an implementation system. In other words, various players, including South Africa and Japan, climatological and infectious disease research, research and administrative organisations, and national and local levels, have organically collaborated to conduct project (research) activities on the development of iDEWS as a platform. Each member organisation was adequately aware of their respective roles and a multidisciplinary approach was realized under effective liaison coordination.

In recent years, cross-sectional research collaboration has been recommended for solving health-related issues; though multidisciplinary collaboration within medical sciences is sometimes conducted, there are not always many cases in which quite different academic fields are effectively connected. Furthermore, the effective collaboration of various organisations, including research institutes, administrative agencies, national and local levels, is very effective in achieving practical application of research results to the society; therefore, this can be recognized as an epoch-making example.

The South African implementation organisations declared an intention to set up the iDEWS Bureau after the completion of the project period in order to continue and further enhance the achievements of the Project. In the future, they aim to position the iDEWS Bureau as part of the national administrative agency, and to further develop the iDEWS Bureau as a platform for collaboration with multiple sectors such as agriculture and disaster prevention. If this can be achieved, it is expected that more positive impacts will be created.

3) Negative Impact

No negative impact attributed to the implementation of the Project was observed as of the time of the Final Evaluation.

4.5 Sustainability

A self-sustainability as well as a self-deployment of the benefits provided by the Project can be expected to some extent at the time of the Final Evaluation.

1) Political and Institutional Aspects

As mentioned in the Section of "*Relevance*", the political importance of the implementation of the infectious disease countermeasures based on the results of the relevant research (based on the reason) while enhancing the technological capability of the development of climate change prediction models and infectious disease prediction models in South Africa is expected to be strongly maintained up to and also beyond the end of the project. The political sustainability of the Project is expected to some extent at the time of the Final Evaluation.

Having said that, the relevant organisations including the member of the iDEWS preparatory committee highly evaluated the climate forecasting-based malaria epidemic prediction models as achieving the sufficient level for the practical application of the forecast information to the prevention and control of malaria, and took practical actions to establish the iDEWS Bureau as of the time of the Final Evaluation. For the meantime, it is anticipated that the iDEWS Bureau will work on the optimisation of the operational guidelines within two years following the completion of the Project, and evidence on the effects of iDEWS on malaria prevention measures will be created. By presenting the evidences that has been developed to the relevant authorities concerned, the member organisations is aiming to position the iDEWS Bureau as part of the national administrative body. Since SAWS and NICD, national authorities for climate projections and infectious disease control, respectively, are members of the iDEWS Bureau, it is desirable that the Bureau steadily strengthen its efforts in terms of policy and institutional arrangements for administrative organisation and public use of iDEWS, while receiving consultations from relevant national authorities and legal advisors, including the said two national authorities.

2) Financial Aspects

Including the cases in Japan, in general, project search activities cannot be financed by the specific research budget of the organisation only and continuous efforts are necessary to obtain support from external organisations such as competitive research funds. Therefore, it is difficult to evaluate the financial sustainability for the continuation of research at the time of the Final Evaluation. However, the research institutes in both South Africa and Japan have a high research capacity, and it is considered that the Project is leading the world with regard to the research on the development of climate forecast-based infectious disease epidemic prediction model with sufficient prediction performance for practical application to epidemic control measures and subsequent interventions based on prediction information. For these reasons, each research institute is considered to have a high capability of research enough to acquire external competitive research funds.

On the other hand, as mentioned above, given that the iDEWS is included as a part of the infectious disease control system in South Africa, the budget for the continuous operation is expected to be secured as an Administrative system. Since future adaptation of the iDEWS in other provinces and neighbouring countries of South Africa is considered, it is desired that a consorted effort by the member organisation of the iDEWS Bureau should continuously be done for packaging the epidemic prediction models, operational guideline, cost analyses for introducing and running the iDEWS.

3) Technical Aspects

As mentioned above, the research capacity of both South African and Japanese research institutes is high, and it is strongly expected that novel research capabilities acquired through the Project will be improved even after the end of the project period. Meanwhile, the Project has succeeded in developing three (3) climate forecast-based malaria epidemic prediction models with sufficient prediction performance for practical use; in particular, the machine-learning-bases model by JAMSTEC, the non-linear statistical model by NEKKEN and the linear statistical model by the UP). In parallel, JAMSTEC and the UWC have been working on the development of mathematical model-based malaria epidemic prediction models individually on the basis of the VECTRI model and the compartmental model, respectively. Though those two mathematical models have not reached a sufficient level for practical application to countermeasures at this point, both JAMSTEC and the UWC are anticipated to continue the development work even following the completion of the Project, since mathematical model-based infectious disease epidemic prediction models have a potential to demonstrate high applicability to other regions.

As described above, the Project aims at the establishment of iDEWS towards malaria and diarrhoea as the infectious disease countermeasures based on the evidences. In addition, since the Project includes the future deployment of the iDEWS in other provinces and neighbouring countries in its activity viewpoints, it is necessary to for the Project prove that the iDEWS functions as a part of the infectious disease countermeasure mechanism in the Limpopo province eventually, on the basis of the accumulation of various individual evidence concerning the effects of epidemic prediction-based interventions and subsequent optimisation of operational guidelines of the iDEWS in consideration of available human and financial resources on the ground. However, the implementation of infectious disease prevention measures based on infectious disease epidemic prediction information is the first attempt in the world; that is, no specialist has such experience. Since the iDEWS Bureau is supposed to continue to work on the creation of evidences regarding the intervention effect on the epidemics and the optimization of operational guidelines, the iDEWS Bureau may be required to obtain the cooperation of external researchers or practitioners with expertise in infectious disease surveillance and/or public health research as needed basis.

4.6 Conclusion

The Project has achieved the improvement of the climate prediction skill on the JAMSTEC SINTEX-F2 and the CSIR Variable Resolution Earth Systems Model (VrESM) and the development of downscaling techniques, especially in the Southern African Region. By utilising the improved climate prediction products, the Project also successfully developed three (3) climate-based epidemic prediction models for malaria. These three (3) models, which have different characteristics, can predict the likelihood of epidemics per season, at different, interoperable, time scales, within target range of accuracy, and the potential extent of said epidemics in once instance. The Project provided a prediction of malaria outbreak in the 2017/2018 season, which led to timeous intervention for malaria control. However, it is necessary to make further scientific evidence to clarify the effectiveness of the intervention. On the initiative of South Africa, the iDEWS Bureau is expected to produce evidence for the optimization of operational guidelines (including countermeasures required based on predictions of outbreaks) after the Project's completion. The iDEWS Bureau is expected to disseminate the prediction results, affected areas in South Africa and even in neighbouring countries. In addition, the iDEWS Bureau is expected to further develop the prediction models, and to explore expanding the application to other regions and other fields such as agriculture, disaster preparedness, etc. in future. The Project's outcome has the potential to make a significant impact if climate forecasting information can be applied to other sectors.

Many academic papers have been published in international journals through collaborative research work under the auspices of the Project with mutual capacity development. Even after the Project's completion, it is expected that research outcomes will continue to be created as a result of the update of the malaria epidemic prediction model based on the climate forecast and the effect of measures based on the forecast information, with a number of research papers expected to be published.

In terms of the evaluation results of the Project, the "*Relevance*", the "*Effectiveness*", and the "*Sustainability*" of the Project are all high, although "*Efficiency*" is moderate due to the delay of the data collection activity and the dispatch of an expert. On the other hand, there are positive "*Impacts*" which will be expected in future practical application of the research findings and outcomes to society, at the time of the Final Evaluation. Therefore, it is considered that the Project's achievement is very high, both academically and as technical cooperation.

The Final Evaluation team makes the following recommendations in order for the Project to attain more positive impacts as well as to consolidate the sustainability further.

CHAPTER 5 RECOMMENDATIONS

The Team made the following recommendations based on the result of Final Evaluation.

(1) Establishment and development of iDEWS Bureau

The proposed iDEWS Bureau should clarify its roles and functions and commence the actual operations by May 2019 when the Project officially ends.

(2) Verification of the effectiveness of the predication information-based interventions for the prevention and control of malaria epidemics

The iDEWS Bureau is required to verify the effectiveness of the intervention from the aspects of prevention, diagnosis and treatment of malaria, which had been taken based on the malaria outbreak prediction information, beyond the Project's completion. The iDEWS Bureau is also expected to optimize the operational guidelines for measures against malaria epidemics based on evidence and to provide information to WHO etc. to demonstrate the evidence and experiences to global activities.

(3) Dissemination of the experience to the neighbouring countries

The iDEWS Bureau should take initiative for the dissemination of the Project's experience and outcomes not only to Mozambique, which shares the border with the Limpopo province, but also the member countries of the Elimination 8. The iDEWS Bureau and Japanese research institutes are expected to maintain their continuous cooperation and joint research on a long-term basis.

(4) Operationalisation of diarrhoeal disease research

The project partners, in collaboration with the iDEWS Bureau, should pursue research on the diarrhoea disease toward further development of climate-based models for the prediction of diarrhoea disease prevalence and incidence variability. The work should consider the utilisation of pathogen data from the laboratory-based surveillance system when available in future.

END

別添 1. PDM version 2（2016 年 10 月 4 日）

Annex 1 PDM version 2
Date: October 4, 2016

Project Design Matrix (PDM) (Version 2)

Project Duration: 5 years from May 12, 2014 to May 11, 2019

Project Title: The Project for Establishment of an early-warning system for infectious diseases in southern Africa incorporating climate predictions

Target Area: The Limpopo Province of the Republic of South Africa

Project Administration:

Project Director: Chief Director, Biotechnology, Department of Science and Technology (DST)

Project Co-Director: Chief Director, Communicable Diseases, National Department of Health (NDOH)

Target Group :

Direct Beneficiaries: a total of 46 researchers (1 from the Applied Centre for Climate and Earth Systems Science (ACCESS); 12 from the South African Medical Research Council (MRC), 6 from the Council for Scientific and Industrial Research (CSIR); 2 from the National Institute for Communicable Diseases (NICD); 6 from the South African Weather Service (SAWS); 1 from the Limpopo Department of Health (LDOH); 2 from the Limpopo Department of Health-Malaria Control (LDOH-Malaria); 3 from the University of Cape Town (UCT); 4 from the University of Venda (UV); 4 from the University of Limpopo (UL); 2 from the University of Pretoria; and 2 from the University of the Western Cape (UWC))

Indirect Beneficiaries: Residents in the Limpopo Province: 5.4 million

Narrative Summary	Objectively Verifiable Indicators	Means of Verification	Important Assumptions
Project Purpose			
A climate-based early-warning system model for infectious diseases control is established as a precursor for further application across southern Africa.	(1) The iDEWS, the installation guide, the operational guidelines, operational costs, etc. are packaged as a precursor model for disseminating to other areas by the end of the project period. (2) The iDEWS is presented to relevant South African authorities as a tool by the end of the project period.	(1) Official report that represent the presentation of iDEWS to the relevant authorities (2) Project report(s)	
Outputs			
1 Climate-based infectious disease epidemic prediction models are developed especially for malaria, pneumonia and diarrhoea.	(1) The iDEWS is developed with the prediction performance of a likelihood of malaria outbreaks with 3-month leadtime. The likelihood will be based on a verification of at least 60% agreement between retrospective prediction and past observations of defined outbreaks by the time of the Terminal Evaluation. (2) The pneumonia prediction is prepared for potential use in early warning with 3-month leadtime. The prediction of seasonal variation will be based on a verification of at least 60% agreement between retrospective prediction and past observations by the time of the Terminal Evaluation. (3) The diarrhoea prediction is prepared for potential use in early warning with 3-month leadtime. The prediction of seasonal variation will be based on a verification of at least 60% agreement between retrospective prediction and past observations by the time of the Terminal Evaluation. (4) More than 4 research papers first and/or co-authored by both Japan and South Africa collaborators related to iDEWS, infectious disease mathematical and statistical models, short-term climate variability prediction system, relationship between climate variability and infectious diseases are published in peer-reviewed internationally recognized journals.	(1) Scientific research articles in reputed international journals (2) Project report(s) (3) Letter of acknowledgement from respective authorities	
2 Operational guidelines of the climate prediction-based infectious diseases early warning system (iDEWS) are developed in the Limpopo Province.	(1) The preparatory committee for iDEWS operation is launched at the Limpopo Province by the time of the Mid-term Review. (2) The iDEWS operational guidelines is considered by authority/-ies concerned by October 2017.	(1) Project report (2) iDEWS operational guidelines	
3 Prediction performance and operability of the iDEWS are verified.	(1) Prediction performance and operability of the iDEWS are evaluated by a pilot application at the Limpopo Province by May 2018. (2) Adaptability of the iDEWS to other areas including other provinces and neighbouring countries is presented to appropriate authorities by February 2019.	(1) Project reports (2) Meeting minutes with approproate authorities	

Activities	Inputs: Japan	Inputs: South Africa	
1 Climate-based infectious disease epidemic prediction models are developed especially for malaria, pneumonia and diarrhoea.	**Japan**	**South Africa**	
1-1. Prospective and retrospective data/information acquisition systems are developed in the areas of infectious diseases and climate variability	**(1) Chief Advisor; (2) Project Coordinator; (3) Other Experts in Epidemiology, Medical Entomology, Climate Dynamics, Public Health and other necesarry areas; (4) Training in Japan for Climate Disease Modeling; (5) Necessary equipment for research and development activities; and (6) Running expenses necessary for implementation of the project activities other than that borne by the South African side.**	**(1) Research Scientists in Epidemiology, Medical Entomology, Climate Dynamics and other related areas; (2) Research Staff and Laboratory Technicians; (3) Office space at ACCESS, UL and DOHL-Malaria; (4) Laboratory space at DOHL-Malaria; (5) Existing Equipment at MRC, CSIR, UL and DOHL-Malaria; (6) Available data, information and specimens related to the project; and (7) Support to the project activities will be made available in accordance with the laws and regulations in force in South Africa, and subject to the availability of resources.**	Necessary cooperation is gained by external project supporters (e.g. ARC and superintendents of public buildings, etc.) for the project activities.
1-1-1. To develop databases of data/information of malaria, pneumonia and diarrhoea respectively from local health information system, archival records of health facilities and so on.			
1-1-2. To determine investigation target sites on the basis of a risk map for respective diseases, which is developed using retrospective data from the database.			
1-1-3. To conduct fact-finding surveys at communities in the targeted sites with regard to incidence and prevalence of respective diseases (including undiagnosed diseases), residents' behaviour that impacts on the prevalence (health seeking behaviour, etc.) and hygienic environment (water quality, air pollution, malaria mosquito insecticide resistance etc.), followed by populating the data into the database.			
1-1-4. To source climatic and non-climatic ancillary environmental data (geographic data, etc.) from ACCESS partner organizations such as the South African Weather Service (SAWS) and the Agricultural Research Council (ARC).			
1-1-5. To observe local-scale meteorological data in the target sites by placing basic observation stations at public buildings.			
1-2. Elucidation of relationships among incidence/prevalence of the target diseases and climate variability (ambient temperature, humidity, precipitation, etc.).			
1-2-1. To investigate the relationship between incidence/prevalence of the target diseases and climate variability using time-series analysis.			
1-2-2. To investigate the relationships of proliferation of malaria vectors with climate variability and malaria incidence/prevalence.			
1-2-3. To investigate the relationship between regional-scale climate variations in the Limpopo Province and their links with the global climate phenomena such as the El Nino Southern Oscillation (ENSO), the Indian Ocean Dipole Mode (IODM) and the Sub-tropical Dipole Mode (SDM).			
1-3. Development of infectious disease mathematical and/or statistical models for malaria, and statistical models for pneumonia and diarrhoea of which local epidemic situation is reflected			
1-3-1. To review existing infectious disease models (related to climate in particular) for malaria, cholera, and pneumonia.			

1-3-2. To develop basic mathematical and/or statistical models for malaria, and statistical models for pneumonia and diarrhorea by modifying existing model(s) or newly developing.			
1-3-3. To calibrate the models by verifying their prediction performance using retrospective and prospective data/information of infectious diseases obtained from the database.			
1-4. Improvement of a seasonal prediction system based on an ocean-atmosphere coupled general circulation model (CGCM) called SINTEX-F; improving its skill, downscaling, extending its lead-time			
1-4-1. To improve the prediction accuracy of SINTEX-F for the short-term seasonal climate variability by enhancing model resolution, implementing better physics and data assimilation in next versions of SINTEX-F on the Earth Simulator.			
1-4-2. To reduce model biases by model validations and intercomparisons among SINTEX-F1, new SINTEX-F2 and other climate models developed in South Africa.			
1-4-3. To improve resolution and lead time for climate prediction of the SINTEX-F for better local-scale prediction performance by using a dynamical downscaling model such as Weather Research and Forecasting model (WRF) and statistical downscaling techniques.			
1-4-4. Interactively with the Activity 1-4-3, to fine-tune WRF downscaling model using local data available from the weather and climate observations at the target areas (Activity 1-1).			
1-5. Development of the climate-based infectious disease prediction models for malaria, pneumonia and diarrhorea			
1-5-1. To develop a climate-based infectious disease epidemic prediction models for malaria, pneumonia and diarrhoea by coupling the infectious disease mathematical and statistical models and the adopted climate prediction model, in light of the relationships among incidence/prevalence of the target diseases, climate variability and proliferation of vectors (Activity 1-2).			
1-5-2. To calibrate the models by verifying their prediction performance using existing data/information of infectious diseases epidemics and outbreaks obtained from the database.			
2 Operational guidelines of the climate prediction-based infectious diseases early warning system (iDEWS) are developed in the Limpopo Province.			
2-1. To launch a preparatory committee for introducing the iDEWS at the Limpopo Province consisting of organizations responsible for epidemic prediction, issuing epidemic/alerting information and implementing countermeasures based on such information.			
2-2. To set criteria for outbreak alerting.			
2-3. To set communication flow of infectious diseases epidemic/outbreak information in the Limpopo Province.			
2-4. To develop an iDEWS operational Guidelines comprising regular reporting of epidemics, issuing outbreak alerting and consequent countermeasures, organogram of iDEWS operation, formats of regular reporting and alerting, etc.			
3 Prediction performance and operability of the iDEWS are verified.			
3-1. To evaluate the prediction performance and operability of the iDEWS through a pilot application at the Limpopo Province.			
3-2. To conduct table-top exercises regarding issuing outbreak alerting and consequent countermeasures at the Limpopo Province.			
3-3. To develop a sustainable monitoring and evaluation system for assessing impacts of the iDEWS on infection control at the Limpopo Province.			**Pre-conditions**
3-4. To verify the applicability of other areas using available data of epidemics, climate and non-climate environment at other provinces of the South Africa and neighbouring countries.			1. Research permissions are obtained by the relevant authority/-ies of South Africa where necessary.
3-5. To hold workshop(s) geared to administrative officers, researchers, etc. in the areas of climate variability and infection control from the government of the South Africa and neighbouring countries for the deployment of iDEWS.			2. Approvals are obtained for medical researches and related interventions/investigations by the ethical committees of the Institute of Tropical Medicine, the Nagasaki University, MRC and other related organization to the project activities.
3-6. To start discussions with administrative officers, researchers, etc. in the areas of climate variability and infection control of the government of the South Africa for the dissemination of iDEWS.			

別添 2. 終了時評価調査の日程

Annex 2. Schedule of Final Evaluation

Name			Dr. Kaname KANAI (Leader)	Ms. Misaki KAWAGUCHI (Cooperation Planning)	Dr. Haruo WATANABE (Observing Member)	Mr. Katsumi ISHII (Observing Member)	Dr. Yoichi INOUE (Evaluation & Analysis)
Date			JICA		AMED		JDS - Consultant
1/7	Mon						18:00 NRT- 22:25 HKG
1/8	Tue						00:30 HKG- 7:30 JNB O.R.Tambo - Pretoria 11:00 Meewing w/ JICA SA Office and a Project Coordinator
1/9	Wed		16:00 - 17:00 Meeting for the Terminal Evaluation@JICA HQ				9:00 - 10:00 Meeting for the Terminal Evaluation @ JICA SA Office 10:30 Interview 1: Dr. Sweijd @JICA SA Office
1/10	Thu						10:00 Interview 2: Dr. Wright @JICA SA Office
1/11	Fri						11:00 Interview 3: Prof. Maharaj on Skype
1/12	Sat		16:10 HND- 20:20 HKG 00:30 HKG- 7:30 JNB	18:00 NRT- 22:25 HKG 00:30 HKG- 7:30 JNB	18:25 NRT- 22:40 HKG 23:50 HKG- 7:05 JNB		Documentation Work
1/13	Sun	AM	7:30 Arrive in JNB 10:45-11:35 JNB- PTG		7:05 Arrive in JNB 10:45-11:35 JNB- PTG		10:45-11:35 JNB- PTG
		PM	10:30 Internal Meeting@O.R. Tambo Airport 11:35 Polokwane - Tzaneen 13:00 Arrive in Tzaneen				
1/14	Mon	AM	8:00 Mr. Kruger @TMI 9:00 Workshop @TMI				
		PM	Interview 4&5: 13:20 Mr. Mabunda @TMI				Interview 4&5: 13:20 Mr. Mabunda @TMI 15:30 Tzaneen - Polokwane 18:00-19:05 PTG-JNB O.R.Tambo - Pretoria
1/15	Tue	AM	8:00 Field Visit - Mamitwa (Clinic & Spraying team)				10:00 Interview 6: Prof. Landman @JICA SA Office
		PM	15:00 Arrive in Tzaneen 15:30 Tzaneen - Polokwane 18:00 PTG -19:05 JNB				14:00 Interview 7: Prof. Engelbrecht @City Lodge Hotel
1/16	Wed	AM	8:00 O.R.Tambo - Pretoria 9:30 Caurtesy Caoo for JICA SA Office				
		PM	16:30 Write up the 1st draft and share info between AMED and JICA				
1/17	Thu		8:50 Scientific meeting				
1/18	Fri		14:00 Discussion Meeting with the Project Director (Dr. Sweijd) @DST				
1/19	Sat		Documentation work Finalization of MM and Final Evaluation Report Preparation for the presentation at the JCC		Documentation work		Documentation work Finalization of MM and Final Evaluation Report Preparation for the presentation at the JCC
1/20	Sun				14:45 Hotel - O.R.Tambo 17:55 JNB- 12:45 HKG		
1/21	Mon	AM	9:00-13:00 JCC & Signing		14:25 HKG- 19:15 NHD		9:00-13:00 JCC & Signing
		PM	Wrap-up meeting				Wrap-up meeting
1/22	Tue		9:45 Hotel - O.R.Tambo 12:30 JNB- 07:05 HKG	9:45 Hotel - O.R.Tambo 12:30 JNB- 07:05 HKG (CX748)			9:45 Hotel - O.R.Tambo 12:30 JNB- 07:05 HKG
1/23	Wed		08:55 HKG- 13:45 HND	09:05 HKG- 14:05 NRT			09:05 HKG- 14:05 NRT

別添 3. 評価グリッド

Annex 3-1 Evaluation Grid (Verification of Implementation Process)

Evaluation Item	Evaluation Classification: Major	Evaluation Classification: Small	Criteria	Necessary data and Information	Data Source	Means of Verification
Probability of achievement of the Project	Project Purpose	Whether the Objectively Verifiable Indicators (OVIs) for the measurement of the achievement level of the Project Purpose of "*A climate-based early-warning system model for infectious diseases control is established as a precursor for further application across southern Africa*" is expected to be fulfilled by the end of the project period.	Degree of achievement of OVIs	① Achievements of OVIs ② Views of related players	① Project documents ② JICA Experts, C/P	① Document review ② Questionnaire ③ Interview
	Outputs	Whether the Output 1 of "*Climate-based infectious disease epidemic prediction models are developed especially for malaria, pneumonia and diarrhoea*" is fulfilled or expected to be fulfilled by the end of the project period.		① Achievements of OVIs ② Views of related players	① Project documents ② JICA Experts, C/P	① Document review ② Questionnaire ③ Interview
		Whether the Output 2 of "*Operational guidelines of the climate prediction-based infectious diseases early warning system (iDEWS) are developed in the Limpopo Province*" is fulfilled or expected to be fulfilled by the end of the project period.		① Achievements of OVIs ② Views of related players	① Project documents ② JICA Experts, C/P	① Document review ② Questionnaire ③ Interview
		Whether the Output 3 of "*Prediction performance and operability of the iDEWS are verified*" is fulfilled or expected to be fulfilled by the end of the project period.		① Achievements of OVIs ② Views of related players	① Project documents ② JICA Experts, C/P	① Document review ② Questionnaire ③ Interview
Inputs	Inputs from the Japan Side	Whether JICA Experts were dispatched as scheduled.	Comparison of plan with actual result	Results of Input	① Input records ② Project reports	Document review
		Whether equipment for project activities was provided as planned.		Results of Input (incl. Information for status of utilization)	① Input records ② Project reports	① Document review ② Direct observation
		Whether C/Ps' training in Japan and/or third countries were implemented as planned.		Results of acceptance of trainees	① Input records ② Project reports	Document review
		Whether local cost from JICA side were implemented as scheduled.		Budget and implementation result	① Input records ② Project reports	Document review
	Inputs from the South African side	Whether C/Ps were appropriately allocated enough to implement project activities.		① Achievement of Input ② Views of related players	① Input records ② JICA Experts, C/P	① Document review ② Interview
		Whether office space for JICA experts was provided.		Achievement of Input	① Input records ② JICA Experts, C/P	① Document review ② Interview
		Whether local cost from Zambian side were implemented appropriately.		① Achievement of Input ② Views of related players	① Input records ② Experts, C/P	① Document review ② Interview
Implementation Process	Planned activities	Whether the project activities were implemented as scheduled.	Comparison of plan with actual result	Accomplishment of project activities	Project reports	① Document review ② Questionnaire
		Whether the PDM was updated in accordance with surroundings of the Project under the agreement amongst relevant parties.		Vicissitude of PDMs and its reasons for modification	Meeting minutes of the Joint Coordinating Committee (JCC)	① Document Review ② Questionnaire ③ Interview
	Technical transfer	Whether methods and/or approaches of technical transfer were appropriate.		Methods and contents of technical transfer	① Project reports ② Experts, C/P	① Document review ② Interview
	Management system	Who, how and how often the progress of the Project was monitored, and consequent findings were reflected to the operation of the Project.		① Progress monitoring system ② Feedback system	① Project reports ② JICA Experts	① Document review ② Questionnaire
		How the decision-making process for modification of the project activities, assignment of personnel, etc was.		Process for decision-making	① Project reports ② JICA Experts	① Document review ② Questionnaire
		How the communication and cooperative relationship amongst players in the Project was.		JCC and other meeting	① Project reports	① Document review

Annex 3-1 Evaluation Grid (Verification of Implementation Process)

Evaluation Item	Evaluation Classification: Major	Evaluation Classification: Small	Criteria	Necessary data and Information	Data Source	Means of Verification
					② Views of related players	② Questionnaire
		Whether Project information was effectively shared.		JCC and other meetings minutes	① Project reports ② Views of related players	① Document review ② Questionnaire
	Ownership and Autonomy	How ownership and autonomy of implementing bodies including C/Ps and beneficiaries were.		Contribution, attitude, etc. for the project activities.	① Project reports ② Views of related players	① Document review ② Questionnaire ③ Interview
	Problems on implementation process	Whether there were obstacles or problems for the implementation of the project activities.		Contributing and inhibitory factors	① Project reports ② Views of related players	① Document review ② Questionnaire ③ Interview
	Follow-up status for the recommendations and indicated matters at Mid-term Review	(1) Development of iDEWS				
		Establishment of cooperative relationship with envisaged users of the iDEWS such as the DOH, DOHL, and the National Disaster Management Centre		Countermeasures taken by the Project and current status	Information from parties and/or persons concerned	① Questionnaire ② Interview
		Resource analyses for the practical operation of iDEWS		Countermeasures taken by the Project and current status	Information from parties and/or persons concerned	① Questionnaire ② Interview
		Additional input of expert(s) with sufficient knowledge and experiences of infectious disease surveillance and response for the development of the operational guidelines of iDEWS		Countermeasures taken by the Project and current status	Information from parties and/or persons concerned	① Questionnaire ② Interview
		(2) Development iDEWS for pneumonia and diarrhea				
		Strict progress management for the completion of the establishment of iDEWS for all 3 target diseases by the end of the project period		Countermeasures taken by the Project and current status	Information from parties and/or persons concerned	① Questionnaire ② Interview
		Establishment of common understanding of the definitions of "*Diarrhoea*" and "*Pneumonia*" since the prevention measures as well as treatment will be different in accordance with the type of diseases and/or causative pathogens		Countermeasures taken by the Project and current status	Information from parties and/or persons concerned	① Questionnaire ② Interview
		(3) Securement of sustainability				
		Practical preparation for the maintenance of "*infectious disease epidemic prediction model*"		Countermeasures taken by the Project and current status	Information from parties and/or persons concerned	① Questionnaire ② Interview
		Capacity development of project members in the Limpopo province for the reinforcement of infectious disease surveillance system through the project activities for the development of iDEWS		Countermeasures taken by the Project and current status	Information from parties and/or persons concerned	① Questionnaire ② Interview
		(4) Verification of applicability of the climate-based infectious disease epidemic prediction models in light of the application to other provinces and neighboring countries				
		Verification of the applicability of iDEWS to other provinces and/or neighboring countries using currently-available data		Countermeasures taken by the Project and current status	Information from parties and/or persons concerned	① Questionnaire ② Interview

Annex 3-2 Evaluation Grid (Five Evaluation Criteria)

Five Criteria	Evaluation Classification: Major	Middle	Small	Criteria	Necessary data and Information	Data Source	Means of Verification
Relevance	Priority	Consistency of the Project Purpose with South African policies with regard to health (infectious disease control), the prediction of climate variability and/or the development of science and technology.		Comparison with South African and/or international policies, direction, etc.	Related policies in South Africa	① Document for related policies ② Related national departments such as the Department of Science & Technology (DST) and the National Department of Health (NDOH)	① Document review ② Interview ③ Questionnaire
		Consistency with Japan's ODA policies and JICA's aid policies	Relativity with prioritized area in Japan's ODA policies		Prioritized area in Japan's ODA policies for South Africa	① Japan's ODA policies for South Africa ② Basic Design for Piece and Health (Global Health Cooperation)	Document review
			Relativity with prioritized area in JICA's aid policies		Place of health assistance in the JICA's aid policies	JICA Country Analysis Paper for South Africa (March 2016)	Document review
		Consistency of the Project Purpose with international trends of measures against global issues			International trends of measures against global issues	Position papers of UN agencies, international partner organizations, etc.	Document review
	Necessity	Relevance of target group	Consistency of needs of target group with the Project Purpose		① Experiences and capacity of counterpart organizations (C/Ps) ② Epidemic situation of infectious diseases such as malaria, pneumonia and diarrhoeal diseases in the South Africa especially in the Limpopo province	① Project documents ② JICA Experts, C/P ③ Health statistics reports	① Document review ② Interview
	Appropriateness of implementation method	Appropriateness of research design (incl. target diseases) and approaches in the framework of SATREPS			Background and/or process for determining research design and/or approaches	① JICA ex-ante evaluation report ② JICA Experts, C/P	① Document review ② Questionnaire ③ Interview
		Special consideration	Special assiduities for gender issues, environment, social grades, environment, ethnic groups, etc.		Views of related players	① JICA Experts ② JICA HQ	① Document review ② Interview
		Japan's technical superiority			① Assistance record of Japan in health sector ② Assistance experiences of Japan in the area of the prediction of climate variability ③ Skills and experiences of JICA experts	① Project documents ② JICA HQ ③ JICA Experts	① Document review ② Interview
Effectiveness	Achievements	Status of the achievements of Outputs	Whether it can be said that research implementation system(s) for the prediction of climate variability, the development of climate-based infectious disease prediction models and the development of the climate prediction-based infectious diseases early warning system (iDEWS) are developed or anticipated to be developed at an expected level by the end of the project period.	Comprehensive judgment from the viewpoint that whether it achieved a desired situation as anticipated.	① Status of achievements of OVIs ② Outputs other than the scope of the project activities	① Project documents ② JICA Experts, C/P	① Document review ② Interview

Annex 3-2 Evaluation Grid (Five Evaluation Criteria)

Five Criteria	Evaluation Classification: Major	Middle	Small	Criteria	Necessary data and Information	Data Source	Means of Verification
			<Output 1> Whether it can be said that climate-based infectious disease epidemic prediction models for malaria, pneumonia and diarrhoea are developed or anticipated to be developed at an expected level by the end of the project period.		① Status of achievements of OVIs ② Outputs other than the scope of the project activities	① Project reports ② JICA Experts, C/P	① Document review ② Interview ③ Direct observation
			<Output 2> Whether it can be said that operational guidelines for malaria, pneumonia and diarrhoea are developed or anticipated to be developed in the Limpopo province by the end of the project period.		① Status of achievements of OVIs ② Outputs other than the scope of the project activities	① Project reports ② JICA Experts, C/P	① Document review ② Interview ③ Direct observation
			<Output 3> Whether it can be said that climate-based infectious disease epidemic prediction models for malaria, pneumonia and diarrhoea are developed or anticipated to be developed at an expected level by the end of the project period.		① Status of achievements of OVIs ② Outputs other than the scope of the project activities	① Project reports ② JICA Experts, C/P	① Document review ② Interview ③ Direct observation
		Probability of the achievement of the Project Purpose	Whether it can be said that prediction performances and operability of the iDEWS for malaria, pneumonia and diarrhea are verified or anticipated to be verified by the end of the project period at an expected level.		① Status of achievements of OVIs ② Outputs other than the scope of the project activities	① Project reports ② JICA Experts, C/P	① Document review ② Interview ③ Direct observation
	Cause-and-effect relationship	Whether the Project Purpose was attained as a result of the achievements of Outputs	Whether there was no logical error from the aspect of cause-and-effect relationship.	Verification of logical relationship	Verification by the Evaluation Team	① Project documents ② JICA Experts, C/P	① Document review ② Questionnaire ③ Interview
			Whether there was any other effective approach for the achievement of the Project Purpose	Verification of implementation approaches	① Verification by the Evaluation Team ② Views of related parties	① Project documents ② JICA Experts, C/P	① Document review ② Questionnaire ③ Interview
	Contributing and inhibitory factors	Appropriateness of the important assumptions	Whether important assumptions are appropriate from aspects of current situation.	Confirmation current situation	Verification by the Evaluation Team	① Project documents ② JICA Experts, C/P	① Document review ② Interview
			Whether important assumptions are appropriate from aspects of current situation and logical relationship	Verification of logical relationship	Verification by the Evaluation Team	① Project document ② JICA Experts, C/P	① Document review ② Interview
		Whether important assumptions are fulfilled.	Confirmation of the current status of "*Necessary cooperation is gained by external project supporters (e.g. ARC and superintendents of public buildings, etc.) for the project activities.*		Records of communications and collaborations with the said external supporters	① Project documents ② JICA Experts, C/P	① Document review ② Questionnaire ③ Interview
			Confirmation of the current status of "*Counterparts do not leave their position so as to affect the outputs of the Project*" as an envisaged important assumption.		Turnover rate of South African researchers	① Project documents ② JICA Experts, C/P	① Document review ② Questionnaire ③ Interview
			Other unexpected factors		① Views of related players ② Other expected and/or unexpected external factors	① JICA Experts, C/P ② Project documents	① Document review ② Questionnaire ③ Interview
Efficiency	Time resource	Whether Outputs were attained as scheduled.			Progress control of the project activities	① Project documents ② Views of related players	① Document review ② Questionnaire ③ Interview
	Quality, quantity and timing of inputs	Whether quality, quantity and timing of inputs were appropriate.	Whether the number and period, areas of expertise and timing of dispatch of JICA expert were appropriate.	Comparison of results and plan	① Record of dispatch of experts ② Attitude and performance of experts	① Input records ② Project documents ③ JICA Experts, C/P	① Document review ② Questionnaire ③ Interview
			Whether types, quantity and timing of installation were appropriate.		① Record of equipment provision ② Utilization status of equipment	① Input records ② JICA Experts, C/P	① Document review ② Questionnaire

Annex 3-2 Evaluation Grid (Five Evaluation Criteria)

Five Criteria	Evaluation Classification: Major	Middle	Small	Criteria	Necessary data and Information	Data Source	Means of Verification
							③ Direct observation ④ Interview
			Whether timing, contents and duration of training in Japan and/or third countries were appropriate, and how the training contributed for the achievement of Outputs.		① Acceptance of trainees ② Views of related parties	① Input records ② Trainees ③ JICA Experts	① Document review ② Questionnaire ③ Interview
			Whether timing, contents, duration follow-up of on-site trainings were appropriate.		① Records of on-site trainings ② Accomplishments of trainings	① Project documents ② JICA Experts, C/P	① Document review ② Questionnaire ③ Interview
			Whether the budget for local costs was appropriate.		Local costs from Japan side	① Input records ② JICA Experts	① Document review ② Interview
			Whether allocation of South African C/Ps and budget for the Project were appropriate.		Local costs from the South African side	① Input records ② JICA Experts, C/P	① Document review ② Questionnaire ③ Interview
		Collaboration with other resources	Whether there was any collaboration with other resources contributed for the achievement of Outputs.		Benefits derived from collaborative activities with other development partners.	① Project documents ② JICA Experts ③ Other development partners	① Document review ② Questionnaire
		Whether there were any contributing factors to efficiency.			Views of related parties	① Project documents ② JICA Experts, C/P	① Document review ② Interview
		Whether there were any inhibitory factors to efficiency.			Views of related parties	① Project documents ② JICA Experts, C/P	① Document review ② Interview
Impact	Probability of achievement of (envisaged) Overall Goals	(Envisaged Overall Goal) Whether the climate variability prediction system, fine-tuned by the Project (SINTEX-F2) and/or short-term climate variability prediction system, newly-developed by the Project are anticipated to be utilized by alternative fields other than the infection disease control after the end of the project period by the self-help efforts of the South African side.		Exploration based on the current status	① Degree of achievement of the Project Purpose ② Verification of Sustainability	① Project documents ② Views of related players	① Document review ② Questionnaire ③ Interview
		(Envisaged Overall Goal) Whether the iDEWS are anticipated to be applied for infectious disease control in other provinces in the South Africa and/or neighboring countries such as Mozambique by the self-help endeavor of the South Africa.		Exploration based on the current status	① Degree of achievement of the Project Purpose ② Verification of Sustainability	① Project documents ② Views of related players	① Document review ② Questionnaire ③ Interview
	Other impacts	Whether there are any positive and/or negative impacts confirmed and/or expected to be generated other than Overall Goal	Positive impacts		Other necessary information	① Project reports ② JICA Experts, C/P ③ Views of related players	① Document review ② Questionnaire ③ Interview
			Negative impacts		Other necessary information	① Project reports ② JICA Experts, C/P ③ Views of related players	① Document review ② Questionnaire ③ Interview
Sustainability	Probability of maintaining the benefits derived from the Project	Political and institutional aspects	Whether the policies related to health (infection control), climate variability and science and technology would be maintained and/or enhanced.		South African related policies	① Related authorities such as the NDOH and the DST ② JICA Experts, C/P ③ Views of related players	① Document review ② Questionnaire ③ Interview
			Whether political and/or institutional support would be gained from related national departments for the practical use of achievements and research outcomes of the Project.		Intention of related national departments and/or discussions with project implementing agencies	① Related authorities such as the NDOH and the DST ② JICA Experts, C/P ③ Views of related players	① Document review ② Questionnaire ③ Interview
		Financial aspect	Whether the budget for benefits derived from the Project will be maintained in the south regions.		South African related policies and budget	① Related authorities such as the NDOH and the DST	① Document review ② Questionnaire

Annex 3-2 Evaluation Grid (Five Evaluation Criteria)

Five Criteria	Evaluation Classification: Major	Middle	Small	Criteria	Necessary data and Information	Data Source	Means of Verification
						② JICA Experts, C/P ③ Views of related players	③ Interview
			Whether the budget and personnel for the enhancement of the benefit will be allocated.		South African related policies and budget	① Related authorities such as the NDOH and the DST ② JICA Experts, C/P ③ Views of related players	① Document review ② Questionnaire ③ Interview
		Technical aspect	Whether the research techniques provided by the Project will be maintained and enhanced autonomously.		① Presence of maintenance mechanism for of technical benefits ② Opportunities to update technical skills	① Project reports ② JICA Experts, C/P ③ Views of related players	① Document review ② Questionnaire ③ Interview
		Contributing and inhibitory factors	Whether countermeasures against envisaged inhibitory factors for sustainability were discussed by the Project and C/Ps.		Views of related players	① Project reports ② JICA Experts	① Questionnaires ② Interview
	Comprehensive sustainability	Whether the comprehensive sustainability is secured or not, in the view of above-mentioned aspects.			Views of related players	① Project documents ② JICA Experts, C/P ③ Views of related players	Analytical evaluation by the Evaluation Team

別添 4. 主要面談者リスト

Annex 4: List of Interviewees

1. **Alliance for Collaboration on Climate and Earth Systems Science (ACCESS)**
   Dr. Neville Sweijd — Director (Project Manager)
   Ms. Tomoka Tawara — Project Coordinator (JICA Expert)

2. **University of the Witwatersrand, Johannesburg**
   Prof. Francois Engelbrecht — Professor

3. **South African Medical Research Council (MRC)**
   Prof. Rajendra Maharaj — Director-Durban
   Dr. Caradee Wright — Specialist Scientist

4. **Limpopo Department of Health-Limpopo (LDOH)**
   Mr. Philip Kruger — Chief Director

5. **Limpopo Department of Health-Limpopo, Malaria Control (LDOH-Malaria)**
   Mr. Erik Mabunda — Director

6. **University of Pretoria(UP)**
   Prof. Willem Landman — Professor

7. **University of the Western Cape (UWC)**
   Prof. Peter Witbooi — Professor

8. **University of Venda (UV)**
   Mr. Hector Chikoore — Lecturer

9. **Nagasaki University Institute of Tropical Medicine (NEKKEN)**
   Prof. Noboru Minakawa — Professor (Chief Advisor)
   Prof. Masahiro Hashizume — Professor

10. **Japan Agency for Marine-Earth Science and Technology (JAMSTEC), Application Laboratory**
    Dr. Swadhin Behera — Director / Principal Scientist
    Dr. Venkata Ratnam Jayanthi — Senior Scientist
    Dr. Masami Nonaka — Senior Scientist
    Dr. Takeshi Doi — Researcher
    Dr. Yushi Morioka — Researcher
    Dr. Takayoshi Ikeda — Project Scientist

別添 5. 投入実績表

5-1　プロジェクトメンバー表

Annex 5-1: List of Project Members

The Japanese Side

Group Leader	Name	Organisation	Position (Title)	Duration				Note
				Start		End		
				Year	Month	Year	Month	
○	Noboru Minakawa	Nagasaki University	Professor	2013	5	2019	5	
	Ataru Tsuzuki	Nagasaki University	Assistant Professor	2014	8	2019	5	
	Yukiko Higa	National Institute of Infectious Diseases	Senior Scientist	2013	5	2019	5	Affiliation Changed in 2018
	Kyoko Futami	Nagasaki University	Assistant Professor	2013	5	2019	5	
	Peter Sean Larson	Nagasaki University	Assistant Professor	2015	5	2017	9	
○	Masahiro Hashizume	Nagasaki University	Professor	2013	5	2019	5	
	Yoonhee Kim	Tokyo University	Associate Professor	2013	5	2019	5	Affiliation Changed in 2018
	Chisato Imai	Nagasaki University	Guest Researcher	2015	5	2019	5	Affiliation Changed in Oct 2015
○	Swadhin K. Behera	JAMSTEC	Principal Researcher	2013	5	2019	5	
	Shingo Iwami	Kyushu University	Associate Professor	2013	5	2019	5	
	Ratnam V. Jayanthi	JAMSTEC	Senior Rescrcher	2013	5	2019	5	
	Takeshi Doi	JAMSTEC	Researcher	2013	5	2019	5	
	Yushi Morioka	JAMSTEC	Researcher	2013	5	2019	5	
	Takayoshi Ikeda	JAMSTEC	Researcher	2014	11	2019	5	
	Tomoki Tozuka	JAMSTEC	Senior Rescrcher	2013	5	2019	5	
	Naoko Miyamoto	JAMSTEC	Senior Research Administrator	2013	5	2015	3	
	Marko Jusup	Hokkaido University	Assistant Professor	2016	10	2019	5	
	Motoyoshi Ikeda	JAMSTEC	Advisor	2014	9	2019	5	
	Masami Nonaka	JAMSTEC	Senior Rescrcher	2017	4	2019	5	
	Noriko Tamari	JAMSTEC	Senior Research Administrator	2013	5	2015	3	

The South African Side

Group Leader	Name	Organisation	Position (Title)	Duration				Note
				Start		End		
				Year	Month	Year	Month	
○	Rajendra Maharaj	South African Medical Research Council	Director, MRC Office for Malaria Research	2013	5	2019	5	
	Philip Kruger	Limpopo Department of Health	Chief Director	2013	5	2019	5	
	Qavanisi Eric Mabunda	Department of Health Limpopo -Malaria	Deputy Director	2016	10	2019	5	
	Jacob Thabiso Ledwaba	Department of Health Limpopo -Malaria	Entomologist	2017	9	2019	5	
	Nyakallo Kgalane Masedi	Department of Health Limpopo -Malaria	Environmental Health Practitioner	2017	9	2019	5	
	Natashia Morris	South African Medical Research Council (Durban)	Research Support Manager	2013	5	2019	5	
	Tsundzukani Masesi	University of Limpopo	Master Course Student (Also a staff of Dept. Health Limpopo assigned for Tzaneen Malaria Institute)	2015	8	2019	5	
	Ngoza Thadi E. Kapwata	South African Medical Research Council	GIS Research Technologist	2015	8	2019	5	
	Jaishree Raman	National Institute of Communicable Diseases	Medical Scientist	2015	8	2019	5	
	Lyn-Marie Birkholtz	University of Pretoria, Department of Biochemistry	Professor.	2015	8	2016	3	
	Shefu Awandu	University of Pretoria, Department of Biochemistry	Ph.D. student	2015	8	2019	5	
○	Angela Mathee	South African Medical Research Council	Director, Environment & Health Research Unit	2013	5	2019	5	
	Caradee Wright	South African Medical Research Council	Specialist Scientist	2015	4	2019	5	Affiliation Changed in 2015
	Eric Maimela	Limpopo Department of Health	Epidemiologist	2013	5	2019	5	
	Nisha Naicker	South African Medical Research Council	Specialist Scientist	2013	5	2017	9	
	Tahira Kootbodien	South African Medical Research Council	Senior Scientist	2013	5	2015	3	
	June Teare	South African Medical Research Council	Senior Scientist	2013	5	2019	5	
	Patricia Albers	South African Medical Research Council	Researcher	2013	5	2016	6	
	Louise Renton	South African Medical Research Council	Chief Research Technologist	2013	5	2018	2	
	Thandi Zwane	South African Medical Research Council	Senior Research Technologist	2013	5	2019	5	
	Mirriam Mogotsi	South African Medical Research Council	Research Technologist	2013	5	2019	5	
	Ishen Seocharan	South African Medical Research Council	Senior Scientist	2013	5	2019	5	
	Wellington Siziba	South African Medical Research Council	Research Trainee	2013	5	2019	5	
○	Kingsley Ayisi	University of Limpopo	Associate Professor	2013	5	2019	5	
	Yehenew G. Kifle	University of Limpopo	Associate Professor	2016	7	2019	5	

Annex 5-2: Dispatch of JICA Experts

Long-term Experts

as of Jan 2019

No	Name	Job Title	Period
1	Ataru Tsuzuki (Mr.)	Expert (Infectious Diseases)	17 Oct 2014 - 16 Oct 2018
2	Jiro Hirau (Mr.)	Project Coordinator	01 Oct 2014 - 21 Oct 2017
3	Tomoka Tawara (Ms.)	Project Coordinator	05 Nov 2017 - 11 May 2019

Short-term Experts

No	Name	Job Title	Period
1	Prof. Noboru Minakawa (Mr.)	Chief Advisor	31 July - 16 Aug 2014
2	Prof. Masahiro Hashizume (Mr.)	Short-term Expert	01 Aug - 10 Aug 2014
3	Dr. Ataru Tsuzuki (Mr.)	Short-term Expert	01 Aug - 19 Aug 2014
4	Dr. Swadhin Behera (Mr.)	Short-term Expert	03 Aug - 10 Aug 2014
5	Dr. Takeshi Doi (Mr.)	Short-term Expert	03 Aug - 10 Aug 2014
6	Ms. Naoko Miyamoto (Ms.)	Short-term Expert	30 July - 10 Aug 2014
7	Dr. Yushi Morioka (Mr.)	Short-term Expert	03 Aug - 10 Aug 2014
8	Dr. Venkata Ratnam Jayanthi (Mr.)	Short-term Expert	03 Aug - 10 Aug 2014
9	Prof. Noboru Minakawa (Mr.)	Chief Advisor	31 Aug - 12 Sep 2014
10	Prof. Noboru Minakawa (Mr.)	Chief Advisor	24 Nov - 06 Dec 2014
11	Prof. Noboru Minakawa (Mr.)	Chief Advisor	03 May - 11 May 2015
12	Dr. Swadhin Behera (Mr.)	Short-term Expert	27 May - 06 Jun 2015
13	Dr. Yushi Morioka (Mr.)	Short-term Expert	27 May - 06 Jun 2015
14	Dr. Takayoshi Ikeda (Mr.)	Short-term Expert	27 May - 06 Jun 2015
15	Ms. Chisato Imai (Ms.)	Short-term Expert	27 May - 07 Jun 2015
16	Prof. Noboru Minakawa (Mr.)	Chief Advisor	28 May - 07 Jun 2015
17	Dr. Peter Larson (Mr.)	Short-term Expert	28 May - 07 Jun 2015
18	Prof. Masahiro Hashizume (Mr.)	Short-term Expert	31 May - 07 Jun 2015
19	Dr. Kyoko Futami (Ms.)	Short-term Expert	19 Jun - 30 Jun 2015
20	Prof. Noboru Minakawa (Mr.)	Chief Advisor	22 Jun - 30 Jun 2015
21	Prof. Noboru Minakawa (Mr.)	Chief Advisor	10 Oct - 17 Oct 2015
22	Dr. Peter Larson (Mr.)	Short-term Expert	10 Oct - 18 Oct 2015
23	Prof. Masahiro Hashizume (Mr.)	Short-term Expert	11 Oct - 18 Oct 2015
24	Dr. Yoonhee Kim (Ms.)	Short-term Expert	11 Oct - 18 Oct 2015
25	Dr. Chisato Imai (Ms.)	Short-term Expert	11 Oct - 18 Oct 2015
26	Dr. Swadhin Behera (Mr.)	Short-term Expert	10 Oct - 15 Oct 2015
27	Dr. Venkata Ratnam Jayanthi (Mr.)	Short-term Expert	10 Oct - 18 Oct 2015
28	Dr. Yushi Morioka (Mr.)	Short-term Expert	10 Oct - 18 Oct 2015
29	Prof. Dr. Motoyoshi Ikeda (Mr.)	Short-term Expert	10 Oct - 18 Oct 2015
30	Dr. Takayoshi Ikeda (Mr.)	Short-term Expert	10 Oct - 18 Oct 2015
31	Prof. Masahiro Hashizume (Mr.)	Short-term Expert	20 Apr - 25 Apr 2016
32	Dr. Swadhin Behera (Mr.)	Short-term Expert	20 Apr - 30 Apr 2016
33	Dr. Takayoshi Ikeda (Mr.)	Short-term Expert	20 Apr - 30 Apr 2016
34	Dr. Yushi Morioka (Mr.)	Short-term Expert	20 Apr - 30 Apr 2016
35	Prof. Noboru Minakawa (Mr.)	Chief Advisor	19 Apr - 29 Apr 2016
36	Dr. Peter Larson (Mr.)	Short-term Expert	21 Apr - 29 Apr 2016
37	Dr. Kyoko Futami (Ms.)	Short-term Expert	07 May - 20 May 2016
38	Prof. Noboru Minakawa (Mr.)	Chief Advisor	10 Jun - 14 Jun 2016
39	Dr. Takeshi Doi (Mr.)	Short-term Expert	06 Jun - 12 Jun 2016
40	Dr. Venkata Ratnam Jayanthi (Mr.)	Short-term Expert	06 Jun - 12 Jun 2016
41	Dr. Swadhin Behera (Mr.)	Short-term Expert	20 Aug - 29 Aug 2016
42	Prof. Masahiro Hashizume (Mr.)	Short-term Expert	21 Aug - 26 Aug 2016
43	Prof. Noboru Minakawa (Mr.)	Chief Advisor	21 Aug - 25 Aug 2016
44	Dr. Swadhin Behera (Mr.)	Short-term Expert	27 Sep - 06 Oct 2016
45	Dr. Takeshi Doi (Mr.)	Short-term Expert	27 Sep - 06 Oct 2016

46	Dr. Yushi Morioka (Mr.)	Short-term Expert	01 Oct - 03 Nov 2016
47	Dr. Venkata Ratnam Jayanthi (Mr.)	Short-term Expert	27 Sep - 06 Oct 2016
48	Dr. Takayoshi Ikeda (Mr.)	Short-term Expert	27 Sep - 03 Nov 2016
49	Prof. Noboru Minakawa (Mr.)	Chief Advisor	27 Sep - 09 Oct 2016
50	Prof. Masahiro Hashizume (Mr.)	Short-term Expert	27 Sep - 06 Oct 2016
51	Dr. Yoonhee Kim (Ms.)	Short-term Expert	27 Sep - 06 Oct 2016
52	Dr. Chisato Imai (Ms.)	Short-term Expert	27 Sep - 05 Oct 2016
53	Prof. Noboru Minakawa (Mr.)	Chief Advisor	04 Feb - 13 Feb 2017
54	Prof. Noboru Minakawa (Mr.)	Chief Advisor	21 May - 24 May 2017
55	Prof. Noboru Minakawa (Mr.)	Chief Advisor	01 Jun - 06 June 2017
56	Prof. Masahiro Hashizume (Mr.)	Short-term Expert	03 Jun - 08 Jun 2017
57	Dr. Swadhin Behera (Mr.)	Short-term Expert	03 Jun - 09 Jun 2017
58	Dr. Takayoshi Ikeda (Mr.)	Short-term Expert	03 Jun - 09 Jun 2017
59	Dr. Yoonhee Kim (Ms.)	Short-term Expert	03 Jun - 09 Jun 2017
60	Prof. Noboru Minakawa (Mr.)	Chief Advisor	13 Aug - 19 Aug 2017
61	Dr. Swadhin Behera (Mr.)	Short-term Expert	06 Sep - 15 Sep 2017
62	Prof. Masahiro Hashizume (Mr.)	Short-term Expert	10 Sep - 15 Sep 2017
63	Dr. Yoonhee Kim (Ms.)	Short-term Expert	10 Sep - 15 Sep 2017
64	Prof. Noboru Minakawa (Mr.)	Chief Advisor	10 Sep - 16 Sep 2017
65	Dr. Venkata Ratnam Jayanthi (Mr.)	Short-term Expert	09 Sep - 17 Sep 2017
66	Dr. Takayoshi Ikeda (Mr.)	Short-term Expert	02 Sep - 17 Sep 2017
67	Dr. Yushi Morioka (Mr.)	Short-term Expert	26 Aug - 17 Sep 2017
68	Dr. Masami Nonaka (Mr.)	Short-term Expert	06 Sep - 15 Sep 2017
69	Prof. Noboru Minakawa (Mr.)	Chief Advisor	25 Jan - 31 Jan 2018
70	Dr. Swadhin Behera (Mr.)	Short-term Expert	25 Jan - 01 Feb 2018
71	Dr. Takayoshi Ikeda (Mr.)	Short-term Expert	25 Jan - 01 Feb 2018
72	Prof. Noboru Minakawa (Mr.)	Chief Advisor	28 Feb - 06 Mar 2018
73	Dr. Swadhin Behera (Mr.)	Short-term Expert	16 Jun - 24 Jun 2018
74	Dr. Masami Nonaka (Mr.)	Short-term Expert	16 Jun - 24 Jun 2018
75	Dr. Yushi Morioka (Mr.)	Short-term Expert	16 Jun - 24 Jun 2018
76	Prof. Noboru Minakawa (Mr.)	Chief Advisor	16 Jun - 25 Jun 2018
77	Dr. Takayoshi Ikeda (Mr.)	Short-term Expert	16 Jun - 29 Jun 2018
78	Dr. Takayoshi Ikeda (Mr.)	Short-term Expert	09 Jan - 20 Jan 2019
79	Prof. Noboru Minakawa (Mr.)	Chief Advisor	13 Jan - 23 Jan 2019
80	Dr. Swadhin Behera (Mr.)	Short-term Expert	14 Jan - 23 Jan 2019
81	Prof. Masahiro Hashizume (Mr.)	Short-term Expert	15 Jan - 20 Jan 2019
82	Dr. Venkata Ratnam Jayanthi (Mr.)	Short-term Expert	15 Jan - 23 Jan 2019
83	Dr. Masami Nonaka (Mr.)	Short-term Expert	15 Jan - 23 Jan 2019
84	Dr. Takeshi Doi (Mr.)	Short-term Expert	15 Jan - 23 Jan 2019
85	Dr. Yushi Morioka (Mr.)	Short-term Expert	15 Jan - 23 Jan 2019
86	Dr. Yoonhee Kim (Ms.)	Short-term Expert	15 Jan - 23 Jan 2019

5-3　南アフリカ人研究者来日

Annex 5-3: South African Researchers' visit to Japan

Name	Sex	Affiliation	Position	Institutes Visited	Date of Dispatch	Date of Return	Purpose of Visit	Duration
Willem Landman	Male	CSIR	Chief Researcher	JAMSTEC	20141018	20141026	Discussion on the research direction and methods regarding the prediction of climate variability in Southern Africa	9days
Asmerom F.Beraki	Male	SAWS	Researcher	JAMSTEC	20141018	20141026	Discussion on the research direction and methods regarding the prediction of climate variability in Southern Africa	9days
Neville Sweijd	Male	ACCESS	Acting Director	NEKKEN, JAMSTEC	20150124	20150131	Participation and presentation at the project open symposium and Research meeting	8days
Rajendra Maharaj	Male	SAMRC	Director MRC Office for Malaria Research	NEKKEN, JAMSTEC	20150124	20150131	Participation and presentation at the project open symposium and Research meeting	8days
Angela Mathee	Female	SAMRC	Director, Environment & Health Research Unit	NEKKEN, JAMSTEC	20150124	20150131	Participation and presentation at the project open symposium and Research meeting	8days
Philippus Kruger	Male	TMI	Senior Manager	NEKKEN, JAMSTEC	20150124	20150131	Participation and presentation at the project open symposium and Research meeting	8days
Peter Wootbooi	Male	UWC	Professor, Department of Math and Applied Math	NEKKEN, JAMSTEC	20150124	20150131	Participation and presentation at the project open symposium and Research meeting	8days
Francois Engelbrecht	Male	CSIR	Researcher, Natural Resources and the Environment	NEKKEN, JAMSTEC	20150124	20150131	Participation and presentation at the project open symposium and Research meeting	8days
Morwamphage Nkadimeng	Male	DOH	Senior General Manager	NEKKEN, JAMSTEC	20150124	20150131	Participation and presentation at the project open symposium and Research meeting	8days
Brilliant Petja	Male	UL	Scientific Manager	NEKKEN, JAMSTEC	20150124	20150131	Participation and presentation at the project open symposium and Research meeting	8days
Modiegi Pertunia Selematsela	Female	DST	Deputy Director: Health Innovation	NEKKEN, JAMSTEC	20150124	20150131	Participation and presentation at the project open symposium and Research meeting	8days
Gcino Mlaba	Female	DST	Assistant Director, Development partnership	NEKKEN, JAMSTEC	20150124	20150131	Participation and presentation at the project open symposium and Research meeting	8days
Ngoza T.E. Kapwata	Female	SAMRC	GIS Research Technologist	NEKKEN	20170423	20170429	Attend research meetings for development of malaria prediction models using climate data	7days
Natashia Morris	Female	SAMRC	Research Support Manager	NEKKEN	20170423	20170429	Attend research meetings for development of malaria prediction models using climate data	7days
Rajendra Maharaj	Male	SAMRC	Director (Malaria Research)	NEKKEN	20170423	20170429	Attend research meetings for development of malaria prediction models using climate data	7days
Fissehatsion A. Beraki	Male	CSIR	Senior Resercher	JAMSTEC	20171111	20171119	Attend research meetings for climate data analysis to develop climate prediction models	9days
Francois Engelbrecht	Male	CSIR	Principal Researcher	JAMSTEC	20171111	20171119	Attend research meetings for climate data analysis to develop climate prediction models	9days
Johan Malherbe	Male	CSIR	Senior Resercher	JAMSTEC	20171111	20171119	Attend research meetings for climate data analysis to develop climate prediction models	9days
Caradee Wright	Female	SAMRC	Specialist Scientist	NEKKEN	20171125	20171202	Attend research meetings for stastical analysis of infectious diseases	78days
Eric Mabunda	Male	LDOH TMI	Deputy Director	NEKKEN, JAMSTEC	20180409	20180415	Attend the workshop and research meetings of seasonal outlook of malaria	7days
Nyakallo Kgalane Masedi	Female	LDOH TMI	Environmental Health Practitioner: Surveillance	NEKKEN, JAMSTEC	20180409	20180415	Attend the workshop and research meetings of seasonal outlook of malaria	7days
Jacob Thabiso Ledwaba	Male	LDOH TMI	Entomologist	NEKKEN, JAMSTEC	20180409	20180415	Attend the iDEWS symposium and workshop	7days
Neville Sweijd	Male	ACCESS	Director	JAMSTEC	20180408	20180415	Attend the workshop and research meetings of seasonal outlook of malaria	8days
Willem Landman	Male	UP	Professor	JAMSTEC	20180409	20180415	Attend the workshop and research meetings of seasonal outlook of malaria	7days
Fissehatsion A. Beraki	Male	CSIR	Chief Researcher	JAMSTEC	20180409	20180415	Attend the workshop and research meetings of seasonal outlook of malaria	7days

Annex 5-3: South African Researchers' visit to Japan

Name	Sex	Affiliation	Position	Institutes Visited	Date of Dispatch	Date of Return	Purpose of Visit	Duration
Neville Sweijd	Male	ACCESS	Director	NEKKEN, JAMSTEC	20181110	20181121	Attend the iDEWS symposium and workshop	12days
Francois Engelbrecht	Male	CSIR	Chief Researcher	JAMSTEC	20181110	20181118	Attend the iDEWS symposium and workshop	9days
Neville Sweijd	Male	ACCESS	Director	JAMSTEC	20181110	20181121	Attend the iDEWS symposium and workshop	12days
Eric Mabunda	Male	LDOH TMI	Deputy Director	JAMSTEC	20181112	20181118	Attend the iDEWS symposium and workshop	7days
Joel Botai	Male	SAWS	Senior Researcher	JAMSTEC	20181112	20181118	Attend the iDEWS symposium and workshop	7days
Caradee Wright	Female	SAMRC	Specialist Scientist	JAMSTEC	20181112	20181118	Attend the iDEWS symposium and workshop	7days
Willem Landman	Male	UP	Professor	JAMSTEC	20181112	20181118	Attend the iDEWS symposium and workshop	7days
Lucky Ntsangwane	Male	SAWS	Senior Manager	JAMSTEC	20181112	20181118	Attend the iDEWS symposium and workshop	7days
Rajendra Maharaj	Male	SAMRC	Director (Malaria Research)	JAMSTEC	20181112	20181118	Attend the iDEWS symposium and workshop	7days
Lucille Blumberg	Female	NICD	Deputy Director	JAMSTEC	20181114	20181118	Attend the iDEWS symposium and workshop	5days

5-4　本邦研修

Annex 5-4 : Training in Japan

	Name	Sex	Organisation	Position	Trainig Site	Trainig Area	Departure Date	Arraival Date	Training Contents	Duration
1	Aluwani Ramalata	Female	University of Limpopo	Junior Lecturer/ Master Course Student	Nagasaki University, Institute of Tropical Medicine	GIS, Statistical Analysis	2015/11/22	2015/12/13	This training is designed for the GIS experts to refine their visualization skill and to acquire new efficient analytic techniques for the swift analysis and visualization with newly acquiring data among malaria occurrence, climate and environmental elements. In addition to the analytic and visualization exercise, the trainee is expected to lean necessary communication skills for the collaborative research with foreign institutes, such as efficient technique for discussion, reporting, presentation, and thesis drafting.	22 days
2	Ngoza Thandi Ethel Kapwata	Female	Medical Research Council (Durban)	GIS technologist	Nagasaki University, Institute of Tropical Medicine	GIS, Statistical Analysis	2015/11/22	2015/12/13		22days
3	Sandile Blessing Ngwenya	Male	University of Venda	Master Course Student	JAMSTEC, Application Laboratory	Data Analysis for correlation among climate and infectious diseases	2015/11/23	2015/12/13	The principal responsible tasks for the University of Venda in the iDEWS Project are (1) maintenance and management of climatic and infectious diseases data from different sources, and (2) Data Analysis of the correlation among the climatic and infectious diseases, especially analysis for malaria outbreaks. The training was particularly designed for a young researcher who needs to learn essential standards for the international collaborative research with foreign institutes. As the fundamental aspect as the researcher for the iDEWS project, the trainee was expected to acquire the basic knowledge such as research ethics, relevant common regulations based on international agreements, as well as necessary skills like efficient and effective presentation and drafting of papers in limited time. In the technical training, the trainee was expected to broadly understand basic and applied techniques in statistic analysis for the utility of the collected data.	21 days
4	Hector Chikoore	Male	University of Venda	Lecturer	JAMSTEC, Application Laboratory	Data Analysis for climate models	2016/11/12	2016/11/30	This training was desinged to learn (1) to model the occurrence of Tropical-Temperate-Troughs (TTTs) and cloud bands over southern Africa and how they may evolve in a future climate. TTTs are an important source of rainfall for the summer rainfall region of South Africa. (2) to model the expansion of the subtropical Mascarene High and how it may affect the north-South pressure gradient and moisture flux onto the subcontinent. a key question is will the tracks of Tropical revolving systems (e.g. Tropical cyclones) be displaced equatorward reducing the chances of flooding in the Limpopo? (3) to undertake downscaling of GCM output for input into regional climate models. Downscaling techniques allow scientists to use global climate model outputs as inputs into regional climate and weather models. Statistical and dynamical approaches may be used.	19 days
5	Gbenga Abiodun	Male	Western Cape University	PhD Student	JAMSTEC, Application Laboratory	Theory and application study for climate information and variability	2016/11/12	2016/11/30	This training was desinged to (1) Understand, and explain meaning of local climatology statistics, and interpret any local climatology information. (2) Understand principles of statistical techniques used in climate studies and outlooks. (3) Understand and explain primary physical mechanisms of the following climate variability. phenomena: oscillations (including El Nino /La Nina, MJO, North Atlantic Oscillation) and Indian Ocean Dipole (IOD).	19 days
6	Mthetho Sovara	Male	Council for Scientific and Industrial Research	Studentship	JAMSTEC, Application Laboratory	Climate Data Analysis	2016/11/12	2016/11/30	This training was desinged for (1) improving technical and scientific skills in modeling by learning new computer programs for analysis of ocean and climate data (2) Discussion new trends in large ocean and climate data sets. (3) Widening future research prospective by discussions with a variety of professionals in the field. This activity includes exchanges of opinions in protocols and cultural values like research ethics which are necessary for international collaboration efforts. (4) Considering the necessary intakes or utilization of new technology (e.g. Supercomputing in South Africa) by acquiring information on the function and capacity.	19 days
7	Caradee Wright	Female	South Africa Medical Research Council	Specialist Scien	JAMSTEC, Application Laboratory	Data Analysis for Infectious Diseases	2017/5/22	2017/6/4	This training includes (1) data quality control & cleaning (overview & theory), (2) descriptive sample analysis I (theory & methodology), (3) Descriptive Sample Analysis I (Operation and application in modeling), (4) Descriptive Sample Analysis II (Application & Interpretation), (5) Biostatical techniques I (Methodology), (6) Biostatical techniques I (Operation and application in modeling), (7) Biostatical techniques II (Methodology), (8) Biostatical techniques II (Verification Skills), (9) Biostatical techniques II (Verification Skills)	14 days

5-5　現地研修

Annex 5-5 : Training in the Republic of South Africa

Date	Training Name	Venue	Course Summary	Participants
10-11 Sep, 2015	Mapping GIS Training	Tzaneen Malaria Institute	1. Operation Guidance for GIS handheld equipment 2. Software exercise	5 Staff from Tzaneen Malaria Institute 1 Japanese expert
14-16 Sep, 2015	iDEWS Lecture Series	University of Limpopo, Boardroom in main Library	Lectures by Japanese & S.A. experts on 1. Malaria Control in S.A. 2. Climate Predicition 3. Statistic Analysis	40 master/ honor students from universities of Limpopo and Venda
24-27 Apr, 2016	Intensive Statistics & GIS exercise Training	Tzaneen Malaria Institute	Intensive Statistics exercise training by Dr. Takayoshi Ikeda and GIS exercise by Dr. Peter Larson	Ms. Tsundzukani Masesi

5-6　供与機材リスト

Annex 5-6: Provision of Equipment

	Procurement	Items	Qty	Allocation	Arrival Date	Usage Status	Note
1	Purchased in S.A.	Dissecting Microscope	4	Tzaneen Malaria Institute	20150311	In Use	Olympus SZ51 Microscope, WHSZ10X-H Eyepices, SZ2-ILST-5 illuminator stand
2	Purchased in S.A.	Digital Microscope	2	Tzaneen Malaria Institute	20150311	In Use	Dino-Lite Premier Digital Microscope
3	Purchased in S.A.	Compound Microscope	1	Tzaneen Malaria Institute	20150311	In Use	Olympus CX22 LED Microscope
4	Purchased in S.A.	Agarose gel electrophoresis chambers	2	Tzaneen Malaria Institute	20150225	In Use	Enduro 20.20 Horizontal Gel Box E1020-20
5	Purchased in S.A.	Power supplies For electrophoresis	3	Tzaneen Malaria Institute	20150225	In Use	Euduro 250 volt power supply E0203-230V
6	Purchased in S.A.	pH meter	1	Tzaneen Malaria Institute	20150216	In Use	Consort, C5010 ph/EC/mV/Temp/DO meter (1 set), General purpose glass bodied electrode P11, Temperature electrode for Automatic temp comensation, Swing-arm electrode stand, Buffer 4, 7m 10 solutions 500ml (1 set, respectively)
7	Purchased in S.A.	Pipette Sets	10	Tzaneen Malaria Institute	20150316	In Use	Nichiryo Co., Ltd, EXII micropipette (0.1-2ul, 2-20ul, 10-100ul, 20-200ul, 100-1000ul, 5 pieces respectively)
8	Purchased in S.A.	Water purifier	1	Tzaneen Malaria Institute	20150305	In Use	Heal Force Bio-Meditech Holdings Limited, Smart-N Water Ultra purification VF type (1 set)
9	Purchased in S.A.	Vortex shaker	1	Tzaneen Malaria Institute	20150305	In Use	Inter Bio-Lab, Inc.Vortex Mixer VM 300 (1 set)
10	Purchased in S.A.	Weighing balance	1	Tzaneen Malaria Institute	20150305	In Use	Adam Equipment, PGW753i (1 set)
11	Purchased in S.A.	Environmental test chamber	1	Tzaneen Malaria Institute	20150305	In Use	Pol-Eko Measurement Laboratory, K 350 Top+INOX (1 set)
12	Purchased in S.A.	ArcGIS Software	1	Tzaneen Malaria Institute	20150305	In Use	Esri South Africa, ArcGIS for Desktop Basic Single Use (1 license), ArcGIS for Desktop Spatial Analyst (1 license)
13	Purchased in S.A.	MATLAB Software	1	University of Pretoria	20150320	In Use	Mathworks Pty. Ltd, MATLAB (Individual) (1 license), Statistics Toolbox (Individual) (1 license)
14	Purchased in S.A.	Portable Turbidity meter	2	Medical Research Council (JHB)	20150311	In Use	HACH, 2100Q Portable Turbidimeter (2 sets)
15	Purchased in S.A.	Portable Multiple meter (pH, Conductivity, Temperture)	2	Medical Research Council (JHB)	20150311	In Use	HACH, HQ40d Portable pH, Conductivity, Optical Dissolved Oxgen (DO), ORP, and ISE Multi-Parameter Meter (2 sets), Probe (1 m IntCal pH, Conductivity, Dissolved Oxygen, 2 sets)
16	Purchased in S.A.	Colorimeter (Chlorine, Free and Total, pH)	3	Medical Research Council (JHB)	20150311	In Use	Hach Pocket Colorimeter II Chlorine (Free and Total) plus pH (3 sets)
17	Purchased in S.A.	Portable Flourimeter	2	Medical Research Council (JHB)	20150311	In Use	ANDalyze, AND1100 Handheald Flourimeter (2 sets)
18	Purchased in S.A.	DPD Free Chlorine Reagent Dispenser	2	Medical Research Council (JHB)	20150311	In Use	HACH, DPD Free Chlorine Reagent SwiftTest Dispenser (3 sets)
19	Purchased in S.A.	Mobile fridge	4	Medical Research Council (JHB)	20150313	In Use	Campmaster Fridge Freezer 40L Thermo (4 sets)
20	Purchased in S.A.	Temperature data loggers	400	Medical Research Council (JHB)	20150311	In Use	LogTag Recorders Ltd, HAX08 LogTagTemperature / RH Recorder (400 sets), LogTag Interface Cradle (1 set)
21	Purchased in S.A.	Dust Track II Desktop model	2	Medical Research Council (JHB)	20150311	In Use	Dust Track II Desktop Model 8530 (3 sets)
22	Purchased in S.A.	Indoor Air Quality Meters (CO2, CO, Temperature, Humidity)	3	Medical Research Council (JHB)	20150311	In Use	TSI Incorporated, IAQ-CALC Indoor Air Quality Meters Model 7545
23	Purchased in S.A.	CO Passive badge	200	Medical Research Council (JHB)	20150311	In Use	Morphix Technologies, ChromAir Passive Badge-Carbon Monoxide 380008-10 (10 sheets / pack, 200 packs)
24	Purchased in S.A.	Micro + smokerlyzer (CO Breath Testing Machine)	6	Medical Research Council (JHB)	20150311	In Use	Bedfont Scientific. Ltd, Micro + smokerlyzer Unit Complete (6 sets)
25	Purchased in S.A.	Hemoacue Hb 201+ Analyser	3	Medical Research Council (JHB)	20150312	In Use	HemoCue, Hb 201 DM System (3 sets)
26	Purchased in S.A.	Infrared tympanic themometer	8	Medical Research Council (JHB)	20150311	In Use	Braun TennoScan Model 4020 (8 sets)
27	Purchased in S.A.	Lancing device with Glucose Monitor	8	Medical Research Council (JHB)	20150128	In Use	ACC-Check Active Glucose Monitor (8 sets)
28	Purchased in S.A.	Electric Weight Scales	6	Medical Research Council (JHB)	20150313	In Use	SECA 813 Digital Flat Scale (6 sets)
29	Purchased in S.A.	Height measurement device	6	Medical Research Council (JHB)	20150313	In Use	SECA 213 Portable Height Measurement (6 sets)
30	Purchased in S.A.	Data entry/collection tablet	8	Medical Research Council (JHB)	20150302	In Use	Samsung Galaxy Note 3 (8 sets)

別添 6. iDEWS 事務局設立意向宣言書

Annex 6 Declaration of Intent to Establish an Infectious Diseases Early Warning System Bureau

DECLARATION OF INTENT TO ESTABLISH AN INFECTIOUS DISEASES EARLY WARNING SYSTEM BUREAU

The South African partners of the Infectious Diseases Early Warning System (iDEWS) project, noted below, with the support of their Japanese partners, have agreed to work toward the establishment of the iDEWS Bureau whose purpose will be to produce and disseminate periodic infectious disease outlook bulletins emanating from the systems developed in the iDEWS project, targeting the Limpopo region, for an initial period of two years, subject to the satisfactory completion of due process and assignment of required funding prior to the implementation.

The authorised representatives of the South African Weather Service (SAWS) & the National Institute of Communicable Diseases (NICD), with the assistance of authorised representatives of University of Pretoria (UP), the Council for Scientific and Industrial Research (CSIR), the South African Medical Research Council (SAMRC) and the Limpopo Provincial Government Department of Health (Limpopo DOH), in collaboration with the Alliance for Collaboration in Climate and Earth Systems Science (ACCESS), supported by the authorised representatives of South African Department of Science and Technology (DST) and witnessed by representatives of the University of Nagasaki (U Nagasaki), the Japan Agency for Marine-Earth Science and Technology (JAMSTEC) and Japan International Cooperation Agency (JICA) subject to stipulated conditions herein, hereby declare their intention to:

1. Conclude negotiations toward a formal agreement for the establishment of the Infectious Diseases Early Warning System Bureau (iDEWS Bureau) by the 15th of January 2019, subject to the successful acquisition of sufficient funding for at least the first two years of operation, and within that period, assess the viability and

means of integration into standard operational application systems at the host institution(s).

2. Co-operate and work toward the establishment of the Infectious Diseases Early Warning System Bureau (iDEWS Bureau) which will entail, *inter alia*:

a) Endorsing funding proposals to fund the iDEWS Bureau's establishment and operation;
b) Utilising the respective institutional administrative apparatus to fulfil any undertaking agreed to in the formal documentation associated with the iDEWS Bureau establishment and operation;
c) Assist with the recruitment of staff and acquisition of necessary equipment and services for the operation of the iDEWS Bureau; and
d) Support and/or play a role in the governance, operation, research activities and other tasks as given in the Discussion Document for the Establishment of the iDEWS Bureau (Appendix 1).

Location: Tokyo, Japan Date: 15th November 2018

Signed by:

Representing SAWS

Representing NICD

Representing ACCESS/CSIR

Representing UP

Representing SAMRC

Representing Limpopo DOH

Supported by:

South African Department of Science and Technology

Witness by:

Representing U Nagasaki

Representing JAMSTEC

Representing JICA

長崎大学 NAGASAKI UNIVERSITY

JAMSTEC

JICA